JULY 1946 ONE SHILLING & SIXPENCE

Plastics

DEALING WITH THE MANUFACTURE, USES AND POTENTIALITIES OF PLASTIC MATERIALS

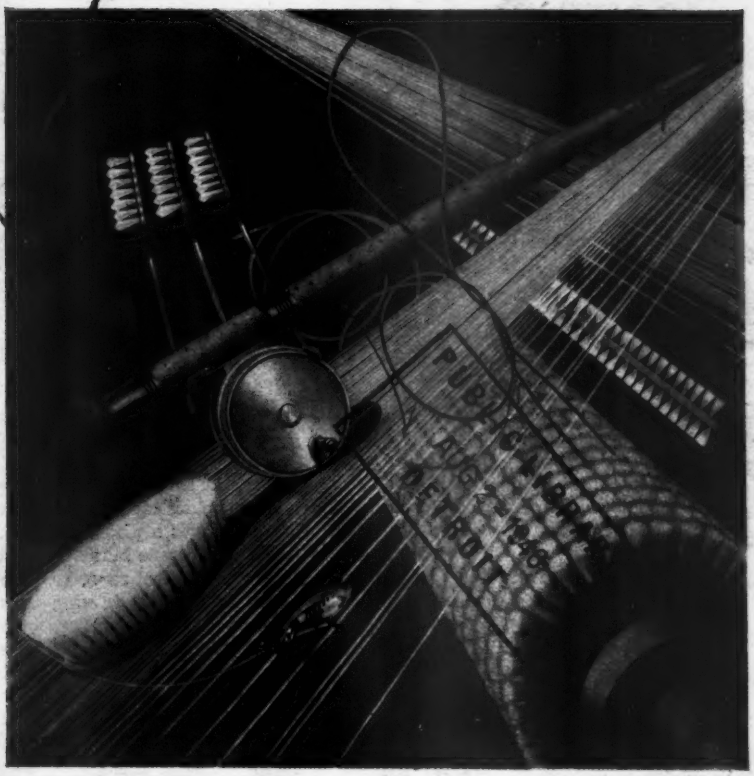

Illustration by Hamzah Carr

NYLON MONOFILAMENT—for the finest surgical sutures or the sturdiest brushes. For full information please write to:

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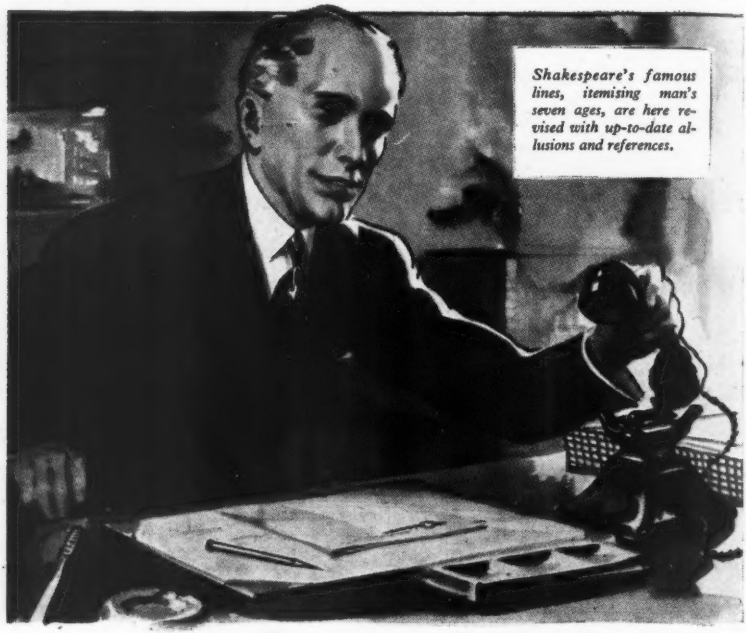
THE SEVEN AGES OF PLASTICS MAN – No. 5



Shakespeare's famous lines, itemising man's seven ages, are here revised with up-to-date allusions and references.

And then the Business Man . . .

Whether or not he enters the plastics industry he will as a business man have plenty to do with plastics. His swivel chair will be plastics upholstered. His typist's machine will have a plastics space bar, plastics keys, perhaps a plastics chassis. His desk will be surfaced with a plastics top impervious to cigarette burns, ink and other stains. His office walls may be lined with plastics murals that reproduce the beauty of oak or walnut veneers. These are but a few of the recent developments which in a few years time may be as familiar as the plastics telephone. Meanwhile plastics research is marching on to new discoveries. We at Erinoid serve in supplying materials to manufacturers for today's actualities, and help and advise about tomorrow's possibilities.

Erinoid LIMITED

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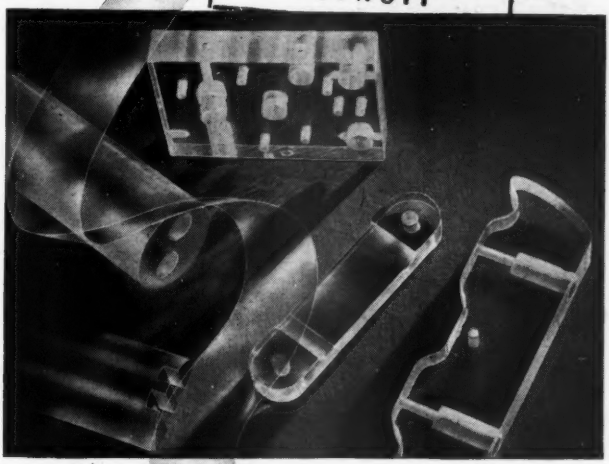
first RADAR



now DISTRENE foil

Radar, one of the most epoch-making inventions of this century, would not have been possible without the help of a material possessing a very low power factor, a high resistance to moisture and a great dimensional stability.

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In DISTRENE FOIL (Orientated Polystyrene Film) the molecules are specially arranged during manipulation so that the tensile strength is increased by 3 times and the flexibility by 10 times.

Power Factor
0·0002-0·0004
Tensile Strength
10,000 lbs/sq.in.
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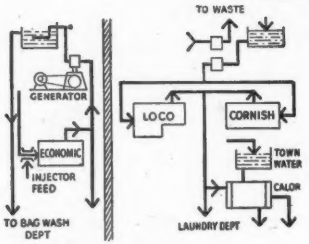
More plants, of all types, adopt proved production-economy technique

Thermal Linkage saves fuel. Thermal Linkage cuts production costs. Thermal Linkage increases output. Those are the three proved reasons why progressive factories everywhere are adopting Thermal Linkage.

Thermal linkage means integrating your various heat-using processes and, as far as possible, operating them as a single co-ordinated heat-using unit. Instead of being independently supplied to several separate points of consumption and the surplus going to waste, heat is circulated and re-circulated from point to point so long as there is work for it to do.



LAUNDRY'S BIG ECONOMY

BEFORE

Thermal Linkage—

A laundry, in two sections (with separate boiler plants), one each side of a road, used 5,550 *lb. of steam per hour and consumed* 41 *tons of coal weekly.*

AFTER

Thermal Linkage—

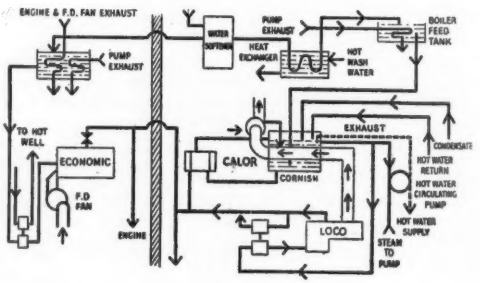
The laundry maintained the same output on a reduced coal consumption of only 31½ *tons per week. Replacement of a condemned boiler was also rendered unnecessary, saving* £6,000 *of new plant.*

URGENT ACTION NEEDED

Fuel efficiency and improved production will remain a pressing need. How much could your existing plant benefit from the application of these principles? No scheme of reconstruction or plant conversion should commence without Thermal Linkage being considered.

FOR GENERAL INFORMATION see Fuel Efficiency Bulletin No. 21 (The Construction of a Factory Heat Balance).

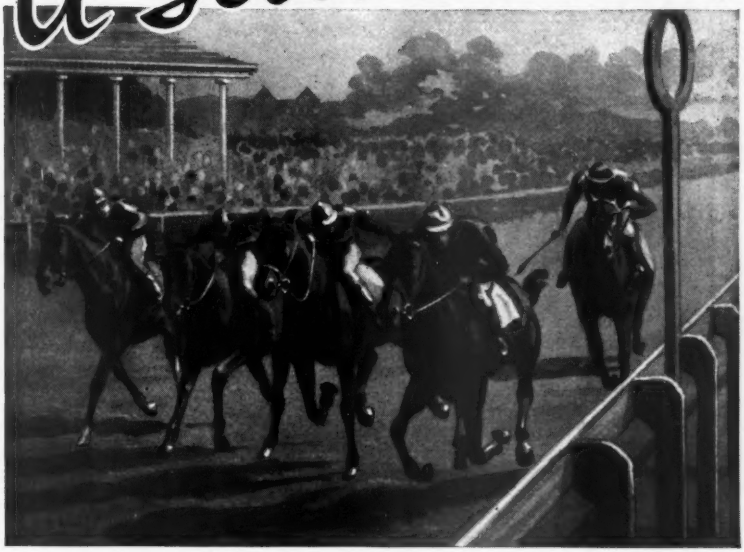
FOR SPECIFIC ADVICE and guidance contact your Regional Office of the Ministry of Fuel and Power.



FOR COMPLETE DETAILS SEE "FUEL EFFICIENCY NEWS" DECEMBER, 1945.

ISSUED BY THE MINISTRY OF FUEL AND POWER

A Good Finish



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The practice of Derwent Plastics has always been to produce a good finished moulding and progress of the Derwent Organisation is built on the quality of its product. We give special attention to finishing and our supervision is of the highest order to maintain the quality for which we are well known.

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B

How employers can find the right executives

MANY employers will remember the tragic waste of talent and ability that resulted from the scramble for employment after the 1914-18 war.

But this time the Government has taken steps to see that talent and ability are not wasted. A free, nation-wide appointments service makes it easy for employers to select just the men and women they need for executive, managerial or administrative posts.

Among thousands now being released from the Forces or from war industry are many qualified and experienced men and women with the capacity for responsible jobs. And with them, younger men of high promise — often with little or no pre-war experience of business or industry, but with qualities of initiative and judgment developed and tested in the Forces.

MATCHING MEN WITH JOBS

The service works through thirteen Regional Appointments Offices, where candidates for responsible posts — men and women from civilian employment as well as from the Services — are interviewed, classified and registered. All who are without previous experience in their chosen field are assessed and "screened" by modern, tested methods to discover their special aptitudes and potentialities.

The result is that the employer seeking a man to fill a certain post — or to train for it — can draw on the whole country if need be: and he is spared many useless interviews, since suitable candidates *only* are submitted for his choice.

The purpose of the Appointments Offices is NOT to find jobs for all applicants, regardless of ability; but to see that those who have ability get the chance to show it, and to offer employers the choice of the best men available for responsible posts.

Since VE-day, more than 30,000 responsible positions have thus been successfully filled. Whatever your needs for experienced or potential executives, you would be well advised to get in touch with your Regional Appointments Office.

Most probably the man you are seeking is already on the register of one of the Appointments Offices — or will be when his release group is reached. In any case the Appointments Offices will spare no efforts to help you find him.

TRAINING SCHEMES

Even if your need for staff is still some months ahead, you will be interested in the training schemes by which promising candidates are being assisted to complete their professional or technical education, or to take courses in business administration.

Write, telephone or call. The Regional Appointments Offices are in the following towns:

LONDON: 1-6 Tavistock Square, W.C.1
CAMBRIDGE: 5 Salisbury Villas, Station Road
READING: 23 Valpy Street
BRISTOL: Lyndale Hotel, Berkeley Square
BIRMINGHAM: 239 Broad Street
NOTTINGHAM: Commerce Chambers, Upper Parliament Street
LEEDS: Greek Street Chambers, Greek Street
MANCHESTER: Commercial Chambers, 47 Corporation Street
LIVERPOOL: Cotton Exchange, Bixteth Street
NEWCASTLE-ON-TYNE: 153 Barras Bridge
EDINBURGH: 5 Rothesay Terrace
GLASGOW: 450 Sauchiehall Street
CARDIFF: 8 Cathedral Road

A General Manager's Appreciation

The following extract from a letter written by the General Manager of a large engineering works is typical of scores of expressions of appreciation received:

"*All the six applicants whose names you sent to me were interviewed. May I say that I was impressed by the consistent high standard of the applicants, and that it was with very great difficulty that a choice was made.*"

Issued by the Appointments Department, Ministry of Labour and National Service, St. James's Square, London, S.W.1.

"ROCKITE" Liquid Resin 1840: a cold setting acid-hardenable phenolic resin suitable for the bonding of wood in constructional work, conforming to M.A.P. Specification D.T.D. 335A and B.S.S. 1204 Type C100. Resin 1840 may also be used for the preparation of cold hardening finishes for specialised uses, such as the one indicated in this illustration, and also for casting purposes.

THE HUMAN TORPEDO

In this Human Torpedo "Rockite" 1840 resin was used as the basis of a protective coating prepared and applied by "JICWOOD" Ltd., Weybridge. The coating was applied to the surface of the wooden hood to prevent the ingress of sea water. This it did successfully even under pressure experienced at great depths to which the structure had to descend, sometimes for long periods. All surfaces of the wooden superstructure exposed to water, were covered with the protective coating; a test requirement being no detectable absorption of water into the wood at a hydraulic pressure of 100 lbs. per square inch.

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The ESC folder, reference PLM/1, contains details of steels eminently suitable for present needs.

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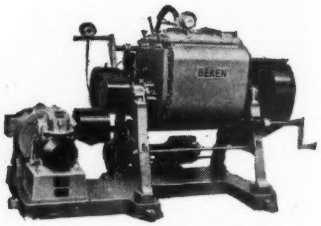
ENGLISH STEEL CORPORATION LIMITED

OPENSHAW MANCHESTER11

"No stirring tale, this!"



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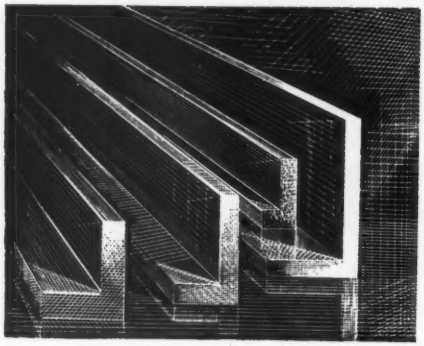

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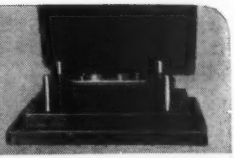

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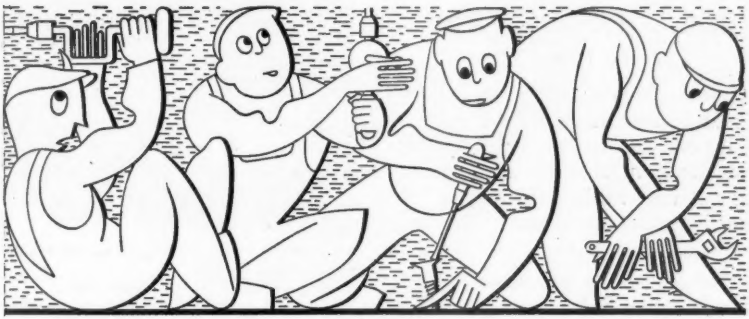
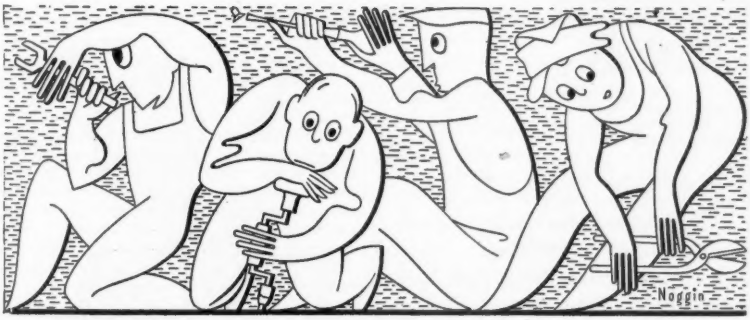


And looking mighty awkward doing it. We don't tell them so, of course, in case they think we're trying to sell them Desoutter Power Tools. But you might.



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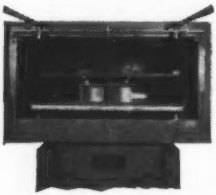
RADIO PRE-HEATING

IN these days of heavy export demands, manufacturers are striving for the maximum output per press. By using Redifon radio pre-heating they will not only achieve this object but also improve the quality of their products.

Redifon radio pre-heating will cut most moulding cycles by over 50%.



A standard heating chamber, for use in the plastics industry, as mounted on Redifon Model R.H.7

Not only does the increased flowability in plastic powders and preforms lead to shorter press-closing times and the possibility of moulding considerably thicker sections, but also the reduced pressure necessary—often reduced by more than half—makes present presses considerably more adaptable.

Full details of Redifon Model R.H.7., 1½ kW radio heater, which can be fitted with a heating chamber specially designed for the plastics industry, are contained in Rediffusion Technical Bulletin No. 6, which will be supplied on request.

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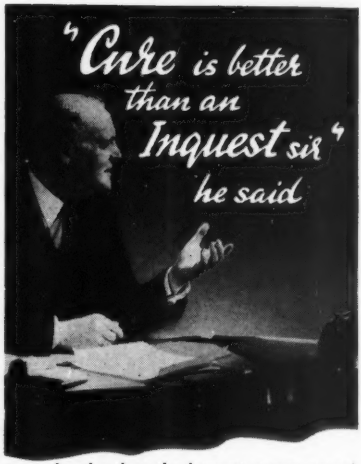

". . . by the time the inquest comes round, the business is dead."

"Well," said I, "What's the cure?"

"Ah! sir," he replied, "Before I can answer that I must know the trouble. When you call in your doctor, his first job is to diagnose. He cannot prescribe the remedy until he has recognised and located the disease.

"It applies in equal measure to the business doctor.

"Do you know, sir, the old Chinese method of paying your doctor so long as he keeps you well, but stopping payment as soon as he lets you fall sick? That is an excellent principle. It is the one I want to put to you now."

"Cure may be better than an Inquest," I chipped in.

"But Prevention is better than Cure."

"Exactly, he agreed heartily. "You've made the point for me. For, Prevention is the basis of my story. It demands the installing of a master instrument giving a graphic presentation and a control at sight, so obvious that potential faults are spotted before they can ever develop.

"Are you interested, sir?"

★ ★ ★

And are you sufficiently interested to want to know the rest of the story? Send 1/- for the Booklet mentioned herein. It will be the best disbursement of petty cash your business ever made. Send to Dept. Y.2. Kardex Visible Control Systems, 1-19 New Oxford Street, London, W.C.1. Tel: Chancery 8888.

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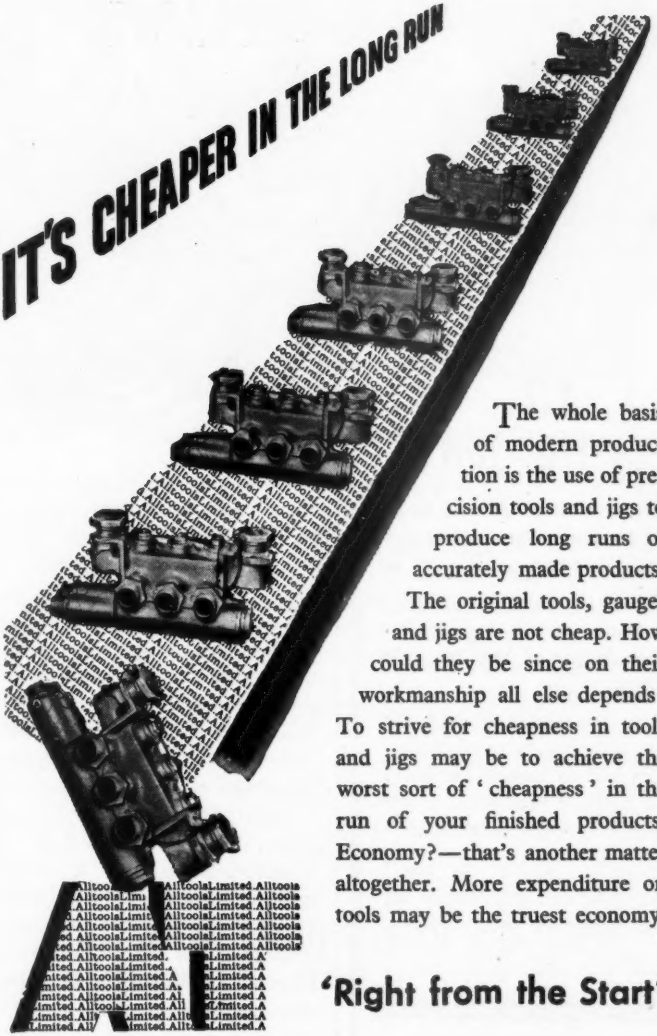

The whole basis of modern production is the use of precision tools and jigs to produce long runs of accurately made products. The original tools, gauges and jigs are not cheap. How could they be since on their workmanship all else depends? To strive for cheapness in tools and jigs may be to achieve the worst sort of 'cheapness' in the run of your finished products. Economy?—that's another matter altogether. More expenditure on tools may be the truest economy.

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Your plastic component will be fit for the job if you consult Moulders of the widest experience such as Crystalate.

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Crystalate's "fit for the job" moulding service will clarify all difficult points for you.

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When the early Egyptians went into the plastics business by moulding wax into face masks and effigies they didn't treat the matter very seriously . . . but modern man expects a great deal from the plastics industry. The complexities of Twentieth Century materials and improvements in processing call for constant progress in heating technique. Recent developments, for example, in high pressure gas burners for heating platens show advantages over steam heating of greater flexibility, cleanliness and economy. Different presses may work at different temperatures or with a temperature gradient across a given platen, if required. Complete combustion is obtained and gas consumption is strictly proportional to output. In warming and mixing processes . . . in heating of preforms . . . in moulding, curing and stoving gas gives accurate, controlled temperatures at low capital and operating costs.

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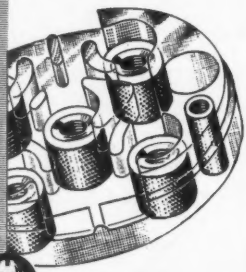

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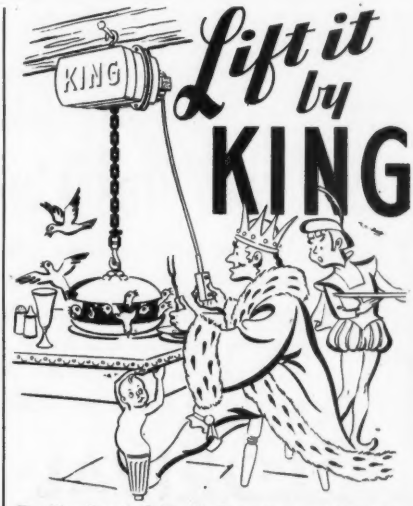

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Vol. X. No. 110. JULY, 1946.

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

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NOTICES

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EDITORIALS

Lunch Hour Plastics

THE Annual Luncheon of the London Section of the Institute of the Plastics Industry is always a pleasant and informative gathering. On June 26 last it was held as usual at the Waldorf Hotel and, if anything, the number present was greater than it ever has been. The most gratifying aspect of the work of the Institute is the steady and indeed sometimes spectacular increase in the membership of what is, after all, a scientific and highly technical organization.

The high attendance was, of course, more especially due to the fact that the chief guest was the Rt. Hon. Sir John Anderson.

The Chairman of the London Section, Mr. G. C. S. Cooper, described Sir John as perhaps the most important guest we have ever had, and indeed it is difficult to name another who has held so many notable administrative posts of distinction. Since he entered the Civil Service, he has served in the Colonial Office, Ministry of Shipping (1917), Ministry of Health and the Home Office. He was Governor of Bengal, Home Secretary and Chancellor of the Exchequer. Of special importance to us is the fact that he was trained as a scientist at Edinburgh and Leipzig. The combination of scientist and career administrator in the one person in the House of Commons is a rare occurrence, and we can rely on him to keep a watchful eye and to give a guiding hand in many of the broad scientific and technical problems that will increasingly be presented for the consideration of the Government. It is no mere chance, we feel sure, that he was requested by Mr. Attlee to accept the Chairmanship of the Advisory Committee on Atomic Energy, which position he will fill with great distinction and understanding.

We were not surprised, therefore, when, in his reply to the Chairman's welcome, he displayed an extensive knowledge of the plastics industry, of the chemical raw materials and the complicated processes that were involved. Sir John was quite capable of telling us, and, indeed, did tell us, what a remarkably fine industry we were in, how wonderful were the chemical reactions to produce plastics, and how diverse and widely used were our finished products.

Perhaps Sir John was preaching to the converted, but we are tremendously grateful, for his words are read by a far greater and more important audience in the outside world than we could pretend to reach. His presence and his talk was excellent propaganda for us. Nevertheless, and we are sure he will forgive us, like Oliver Twist, we want more of it—and perhaps a little bit different fare.

Sir John Anderson also drew attention to the smallness of our industry, which in its effect on national income and endeavours cannot, of course, be compared with the much vaster industries such as coal, steel, shipping, agriculture, etc. Indeed, on such comparison we are pretty small beer, but we have grown pretty rapidly, we consider, from, say, 1914, when the output of the plastics industry was indeed negligible. It is true that production figures are not available, but if we put the production of all plastics about the year 1939 as roughly 30,000 tons per annum we shall not be very far out. To-day we are equally in the dark, but we have certainly doubled our 1939 output which is probably about 80,000 tons per annum. This quantity is rapidly increasing and is as yet independent of the very large quantities of nylon that are being produced in filament form.

Our main point in reminding readers

of these figures, however vague they may be, is to insist on the sharp upward curve of production during the past seven or eight years. Were the average financier to look at this curve and at the downward curve for the production of coal since the year 1913, we wonder if he would be guided solely by the relative outputs in choice of investments.

It would be well to remember that 70,000 to 80,000 tons of plastics as sold to the moulders, fabricators, etc., are worth about 15 to 20 million pounds sterling. To carry our argument to an absurd degree we can point out that one pair of nylon silk stockings weighing ¾ oz. is sold for about 8s. (U.S.). This works out at £19,000 per ton against 40s. per ton for coal from which it is derived.

Guest for 1947

WERE we to have a choice for the chief guest of the 1947 annual luncheon of the Institute of the Plastics Industry, we should plump for the Minister of Fuel, and would ask him to talk to us about coal and what the Government's policy is regarding it.

For good or ill, the coal-winning industry and eventually its satellites, the gas and electrical industries, are scheduled for nationalization. We need not here go into the wrongs or rights of the matter, but since coal is the life blood of the plastics industry, just as it is the life blood of the chemical industry, we have a right to know where we are going from here.

We should like the Minister, always presuming he would accept our invitation, to tell us if the Government regards coal merely as a mineral for sale anywhere in the world because the production (174,000,000 tons) is so large in comparison with other raw materials and the total income (£340,000,000) so dazzling, or does it regard coal as a precious compound and as a raw material to be made into by-products, intermediates and finished chemicals and products of far greater value. We want to know the long-term policy, but under present conditions cannot expect quick results.

In other words, would it not pay handsomely and would it not be more logical for the world's economy to use all our coal to the best advantage, converting most of it into chemicals, plastics, fibres and so on which can be much more profitably exported?

Frankly, we would wish to take over permanently as much of Germany's chemical and plastics as we can. Before 1914 and between the two wars Germany bought vast quantities of our coal at low prices, converted it into a vast range of materials, often for resale here and more largely to the whole of Europe, South America, Asia and Africa.

We could, if we wished, become, to a great extent, the chemical and technical factory of Europe, producing high-priced semi-finished and finished materials, employing much greater numbers of skilled technicians and scientists and creating, at the same time, very valuable chemical engineering and precision instrument industries.

We presume it axiomatic, since we are exporting vast quantities of whisky, that a debtor nation should export her costliest goods, just as France exports fashions and perfumes and Holland diamonds. Let us carry this axiom a big stage farther.

We know nothing of economics, but we are sure the following figures should mean something to somebody.

Coal Production (Tons)	
1913	287,000,000
1939	231,000,000
1945	174,000,000
Coal Price (Pit Head Per Ton)	
1913	11s. 0d.
1939	17s. 11d.
1945	39s. 6d.
Number of Coal Workers	
1913	1,070,000
1939	766,000
1945	709,000

Thus, 709,000 workers produced about £340,000,000 worth of coal in 1945, so that each worker may, for the present argument, be considered responsible for the production of £480 worth of coal per annum. This is the figure for pit-head coal and to make a stricter comparison

with what follows the final sales price should be taken.

Let us, in contradistinction to the above, take Imperial Chemical Industries, Ltd., as an example of a chemical-producing firm, employing and converting large quantities of coal into chemicals. A large proportion of the output, however, is of pure inorganic origin and should be taken into account. However, the following figures are enlightening.

Aggregate proceeds (1945)	£105,300,000
Number of factory workers	70,000
Total employees (about) ...	80,000

So that each worker may be considered responsible for the production of goods to the value of £1,300-£1,500. We should like to ask our, at present, imaginary guest whether there is anything of value in these comparative figures and when we shall stop selling coal abroad.

P.V.C. Racket

A SHORT while ago we were delighted to note that the " Daily Herald " had given publicity to the notes we had written on the excessive prices demanded and paid for p.v.c. sheeting.

This daily paper is pursuing the good work of exposing poorly fabricated material and we have pleasure in reproducing a note contained therein on July 4.

Certain types of low-grade coupon-free plastic cloth, in modernistic colours, at 8s. to 10s. 6d. a yard, are annoying women shoppers.

They find within a few days that the—

Material has faded badly;

Pattern has worn off;

Garment has ripped at the seams.

Mushroom firms are flooding the market with defective sheeting, some of it made from cable scrap.

Retailers are making up this sheeting into mackintoshes, curtains, sponge bags, swimming caps and brassieres. Complaints are so numerous that many shopkeepers now refuse to stock the material.

After testing samples of the cloth at its research station, the Retail Trading-Standards Association warned its members to handle it " very gingerly."

Test results, far below the normal for textiles, were:—

Tensile strength: 18 lb. a sq. in.

Bursting strength: 24 lb. a sq. in.

Seam strain: 11 lb. an in.

Colour: Fading and change in three days' dull weather.

" Much damage has already been done to public confidence," said Mr. R. Diplock, the Association secretary.

" It is a great pity that such material was ever put on the market at this stage." said the Association chairman, Mr. Ronald Schofield. " Complaints from the public have been pouring in."

The cost of making this material into raincoats varies from 35s. to 45s. A London shopper who examined seven raincoats found three badly ripped at the seams.

But the no-coupon bait attracts women shoppers.

It only remains for us to stress that there are reputable firms with a strong sense of responsibility manufacturing sheet of excellent quality and of " non-fading " colours, as angry as we are that such conditions exist. The danger is, of course, that all p.v.c. may be classed as " poor " by the public.

EXPORT MARKET ORGANIZATION

A NEW organization, to be known by the short title SCIEX, Scientific Exports (Great Britain), Ltd., has been formed to co-operate the exporting activities of a number of leading British manufacturers of a wide range of scientific supplies. The parent companies, all firms of good standing and with export experience, include Allen and Hanburys, Ltd., Baird and Tatlock (London), Ltd., W. Edwards and Co. (London), Ltd., Adam Hilger, Ltd., Hopkin and Williams, Ltd., W. Watson and Sons, Ltd., and E. R. Watts and Son, Ltd. Their plans include group selling in overseas markets by a development of the existing agency organizations of the individual members, among whom five are members of the Scientific Instrument Manufacturers' Association of Great Britain. A reception to inaugurate this new company was held in London during June. The value of a co-operative selling organization with export market cannot be over-rated. It offers the most economical and efficient method of obtaining the widest possible overseas distribution, apart from which there are few companies who wish to maintain and operate a costly export organization of their own in London.

The Simplicity of Chain Molecules

On May 17 we listened with extreme pleasure to Professor W. T. Astbury's talk on the above subject in the popular "Science Survey," broadcast every Friday. The matter is normally fascinating and important to us, but Professor Astbury described it so simply and clearly that we have obtained permission of the B.B.C. to reproduce his words in full.

THAT Professor Astbury was well fitted to deal with the subject under discussion received emphasis in the introductory remarks of Professor Andrade. He said that Professor Astbury started his scientific studies at Cambridge, then came to London shortly after the war of 1914-18 to work with Sir William Bragg on applying X-rays to problems of crystal structure, especially of organic chemicals. Later he applied the X-ray method to the structure of textile fibres and other things that grow.

PROF. ANDRADE (continuing): What we'd like now is for you to tell us in a general way about the science of fibres.

PROF. ASTBURY: Right . . . it'll be a good idea, I think, to rattle off just a few of the things I'm going to talk about—by implication at least, whether or not I actually mention them again. They're hair, wool, cotton, silk, rayon, nylon, muscle, nerves, skin, rubber, wood, bacon and eggs, gun-cotton, gun turrets, insulin, polythene, finger nails, jelly-fish, monkey nuts, permanent waves—and in fact a whole hodge-podge of things that seem to have nothing to do with one another.

They seem to have nothing to do with one another, of course, because in the ordinary way we don't look below the surface. But to get a proper view of things, we've got to penetrate much deeper than that; we've got to look at the tiny units they're made of, the molecules. They're invisible to the eye, as you know, but that needn't bother us too much if we look at them through the eyes of the mind.

Molecules are built from atoms—all sorts of combinations of atoms—and every substance has its own particular kind of molecule. Now the crux of the matter with regard to fibres is this, that they're constructed from molecules of the same general shape as the fibres themselves—very long thin things, that can be bent about, too, and more or less tied into knots.

PROF. ANDRADE: I suppose one can say that the atoms are put together in these fibres more or less like vertebræ in the snake's backbone.

PROF. ASTBURY: Yes, that's about it.

PROF. ANDRADE: Quite a contrast to the ring-shaped more or less rigid molecules Sir Robert Robinson was talking about a fortnight ago.

PROF. ASTBURY: Oh yes, they're arranged quite differently. Well, in each molecule of natural fibres such as wool there are thousands of atoms, and they're put together in a very cunning and complicated manner; it's that, of course (the way they're put together) that makes a wool molecule different from, say, a cotton molecule) and in the end gives the wool fibre all those fascinating properties that make it what it is.

To my mind this story is one of the romances of our time. It has only recently dawned on us what it's all about, but in reality it's much older than mankind and stretches right back to the beginnings of life. We're rightly proud of what has been achieved in the textile industries by traditional craftsmanship, but now it turns out that Nature has been doing similar things with molecules for ages, and doing them infinitely better. Take, for instance, the skin of the common earth worm. There's a fabric if you like—and that's nothing! Living nature is, in fact, one gigantic textile business, and now that we've discovered this and are taking the lessons to heart and applying them scientifically, a whole new world is opening up—a world in which medical men and wool sorters, plastics manufacturers and breeders, cotton spinners,

gardeners and tyre merchants, are all partners in a single great adventure.

The password to this world is "chain-molecules." It is an open-sesame of much magic, and the key to so many scientific and industrial advances, that I wonder politicians have not got hold of it yet. Chain-molecules is the scientist's name for these long, flexible molecules from which fibres are made. How it is done is in principle simplicity itself. Fibres are constructed from long, thin, invisible molecules in much the same way as yarns are constructed from long, thin, visible fibres. That sounds obvious when you put it like that, but for all that it has taken a lot of working out, and it represents one of the most comprehensive generalizations in science.

As a first example let us look at the difference between the beautifully elastic animal fibres, such as hair and wool, and the comparatively inelastic vegetable fibres, such as cotton and flax. The animal fibres are made from long protein molecules called keratin, and the vegetable fibres from cellulose. Now the cellulose molecules are inextensible chains, so (when you stretch or make a sharp bend in a cellulose fibre) the chains soon start to slip past one another and the fibre stays stretched—it is like the process of spinning yarns that textile people call "drafting." But this is not so with the wool fibre. Its molecules are long folded chains, something like the conventional sea-serpent; and when you stretch wool (or any animal hair for that matter) the molecules themselves stretch out like minute springs, only to fly back again when you let go, especially if the fibre is wet.

An additional point is that these keratin chains are linked side to side by shorter chains, so as to build up ladder-like arrangements, and it is these long ladders really, and the kinds of rungs in them, that are at the bottom of everything that wool and hair does. There is any amount more to it than can be conveyed in these few words, of course, but you will get a pretty good idea of the scope of things when I tell you that all the basic science of the wool industry rests on it. And in a lighter vein, I might add that it forms an impressive part of the science of beautification, too—I mean it explains how permanent waves and curling paper waves work.

The purely industrial aspect (however large it looms at the moment) is not so terribly important in the long run as the biological and medical side. You see, wool isn't only a textile fibre, it's a protein, and the proteins are overwhelmingly the most important compounds in life. Life as we know it does not manifest itself without them—on the molecular level they more or less are life. They're also chain-molecules, but chain-molecules with special peculiarities; and it is these peculiarities that have been revealed primarily by X-ray diffraction studies of the structure of wool and hair. These first showed the nature of protein elasticity, and how the chains are sometimes stretched out straight, sometimes wavy, and how in one class of protein molecules they are even folded up into highly distinctive packets, so to speak. And perhaps most exciting of all to many people, they showed that the molecules in muscle, like those in wool and hair, are also spring-like in their action, and that they fold and unfold with every movement we make.

You'll remember I said we're now taking these lessons to heart and are beginning to apply them ourselves systematically. When I said that, I was referring to the great and still developing industries that are concerned with the many kinds of man-made fibres, plastics and rubbers. The raw materials of all these are chain-molecules, and the tricks we make them perform are our present homework. We cannot yet make cellulose and proteins ourselves, but we can do the next best thing, and that is to refashion and adapt to our own ends the supplies that Nature prefabricates. That is what is done in the rayon industry; the cellulose molecules are dissolved out of wood and such-like, or protein molecules out of nuts and beans and milk, and then they are reprecipitated and spun into filaments in the

(*Continued on p.* 368.)

Plastics for Industrial Plant Contacting Chemicals (Contd.)

Continuing from the June issue, the author deals further with the desirable criteria for plant construction materials, and gives additional instances of usage of plastics to meet particular problems.

By C. H. BUTCHER

HIGH mechanical strength is desirable, especially for plant parts which are likely to be exposed to heavy stresses, as with pressure vessels and such accessories as stirrers, rollers, footstep bearings, etc. Such materials as Haveg and Keebush have a bending strength of between 6,000 and 7,000 lb. per sq. in., and a compressive strength of 10,000 lb. per sq. in., but if necessary, steel reinforcement can be added, although the tensile strength of Keebush A itself is in the neighbourhood of 15,000 lb. per sq. in. As regards likelihood of mechanical injury or damage from shock, it will be evident that such a material does not chip or fracture very easily when the impact strength is about 350 lb. per sq. in. Nevertheless, it is readily machinable; it can be cut with a saw, turned in a lathe as for the facing of flanges, and drilled to accommodate flange bolts.

The mechanical properties of the available forms of plastic suitable for industrial plant show variation, one to another; some are rock hard, which may be an advantage in certain uses. Yet if the material is easily machined it may be adapted by slight alteration, and also repaired (most likely in situ at low cost) after suffering accidental damage. It is also well to remember the occasional need for chemical plant to be altered to meet a change of conditions, commonly involving the fitting of additional connections, which, in the case of a good plastic, is done without much trouble. Neither should such a material deteriorate unduly with age, especially when standing idle. In the case of Keebush, there is no delay in resuming service after long non-working periods; this is an advantage which is not always taken into account, although one which rarely applies in the case of plant made of metal where corrosion may result from conditions obtaining in a state of idleness apart from corrosive agencies and environment in use.

As a further feature, plastics for plant construction have a useful property in being electrical insulators. This is advantageous when employed for the construction of electrolytic cells, electro-plating vats, and in other situations where both electrical and chemical resistance are necessary in the efficient operation of a process. As an alternative, chemical stoneware is both bulky and extremely heavy, although a considerable number of stoneware tanks have been installed at the works of accumulator manufacturers, and, likewise, in the electro-plating and electro-chemical manufacturing industries. Experience, however, is now pointing to the advantages secured by the considerably lighter plastics, which, when desired, can be made conductive of electric current by the addition of appropriate fillers.

Plastics in form of varnishes are commonly used as a protective coating for metal. The chief types are modified phenol-formaldehyde resin varnishes, phenol-formaldehyde resins incorporated in oil varnishes, glyptals in oil varnishes, and chlorinated rubber varnishes. With the exception of the latter, they may be used up to temperatures of about 200 degrees C. Such protective coatings offer an alternative to anti-corrosion paints whose general durability is based on the presence of inhibitors apart from the

enhanced moisture and alkali resistance of other ingredients. The glyptal resins in a suitable vehicle have been used for painting the kerbs of centrifugals engaged in the refining of cane suger, mainly to counteract adherence of crystals. Cellulose nitrate has found application for preventing the corrosion of iron pipes buried in the soil, especially in situations where conditions are highly corrosive ("Chem. Met. Eng.," 1940, 47/602).

In other and distinct directions the need to resist direct corrosion by acid has been emphasized, as where a coating of plastic has found useful application in covering the steam-heated coils of washing machines engaged in removing poisonous spraying residues from apples prior to employment in the food-preserving industry. In this situation experience showed that copper tubing flaked to a considerable depth and became soft and spongy below newly exposed metal when a dilute solution of hydrochloric acid (1.25 per cent.) was employed as the washing medium at a temperature of 50 degrees C. ("Agric. Eng.," 1937, 18/261). Steel tubing was also destroyed rapidly, but all metals had a greatly lengthened useful life when coated with a Bakelite vehicle, preferably incorporating aluminium powder.

At the works of the Pittsburgh Chemical Co., in the United States, storage vessels for potassium metabisulphite are in form of steel tanks coated internally with plastic of the urea-formaldehyde type ("Chem. Met. Eng.," 1945, 52/231). Such vessels provide needful protection against contamination as well as corrosion, the former being especially important as a large proportion of the metabisulphite goes to wineries for use as a fermenting arrester and settling agent, where, having higher purity, it has advantage over anhydrous bisulphite of soda previously employed. Another large user of potassium metabisulphite is the photographic industry; following that, in substitution for sulphur dioxide in the treatment of dried fruits. The plastic-coated steel tank is cheaper than a stainless-steel construction, which is commonly favoured when most of the plant for metabisulphite manufacture is made of certain grades of stainless steel. The raw materials entering this chemical process are 50 per cent. caustic potash and a bisulphite solution obtained by neutralizing normal potassium sulphite with liquid sulphur dioxide. Iron as low as 0.009 per cent. gives the metabisulphite crystals an undesirable yellow coloration, but the trades concerned demand an iron-free white product, and with this object in view plastic-coated tanks have been installed.

Filter-press cloth used in Germany during the war was commonly made of Pe-Ce, a synthetic textile akin to Saran or polymerized vinylidene chloride. Such cloth claims to give complete resistance to hydrochloric acid at any concentration, likewise to nitric acid at strengths up to 50 per cent. But although so highly resistant to hydrochloric acid, it suffers deterioration under the action of free chlorine and certain chlorine compounds. Nevertheless, filter cloth made from the vinyl and vinylidene polymers has now passed the experimental stage, and its use is extending in filtration problems wherever corrosion is likely to be experienced. In the presence of strong acid or alkali the use of such filter cloth not only eliminates the heavy expense of frequent replacement, but also the consequent cost of time which must be charged to a process in terms of equipment standing idle while filter cloths are being changed. In the filtration of certain acid dyestuffs the use of such filter cloth has been especially encouraging.

Polymers of acrylic derivatives, in the experience of E. I. du Pont de Nemours, in the United States, have proved suitable for the construction of pumps for certain corrosive chemicals. One works, also in the United States, has installed a number of plastic tubes carrying hydrofluoric acid, and are of the opinion that they will overcome the serious corrosion troubles previously existing ("Chem. Met. Eng.," 1944, 51/99). These plastic tubes prove initially more expensive than the copper tube previously employed, but the

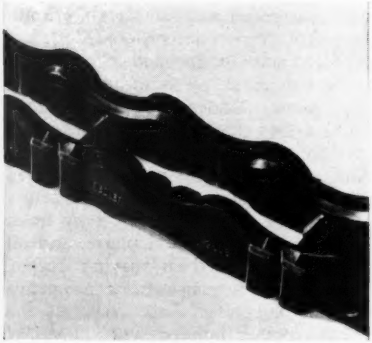


Fig. 4.—Links for the chain of a conveyor for handling bleaching powder. Moulded in Bakelite by De la Rue Plastics, Ltd. (Redler Conveyors, Ltd.)

non-corrosive property of the plastic in contact with hydrofluoric acid has more than justified this higher initial cost. Although these tubes were only ¼-in. bore, corrosion in the case of copper was so drastic that the cost of making replacements was more serious for labour than for materials employed. The nature of the plastic is not stated, but it is believed to be based on polymers of vinyl or vinylidene.

Bakelite material with medium shock resistance, showing exceptionally good life in contact with chemicals, has been employed for moulding the links of conveyors and chain drives at chemical works. The tensile strength of the individual links in such chains would be normally upwards of 7,500 lb. per sq. in., but much higher when special moulding powder formulæ are adopted. The coefficient of thermal expansion for the Bakelite material is 0.00002 per degree C., and the weight varies from 80 to 120 lb. per cubic ft., compared with iron or steel at 480 lb. Fig. 4 shows some of these links as used for a special conveyor made by Redler Conveyors, Ltd. This installation was supplied for handling bleaching powder, which, due to its latent chlorine, had the property of seriously attacking and corroding any ferrous metal previously used for conveyor chains. Details of the actual tension load on the chains when in use are not available, but the makers of the conveyor stipulated that Bakelite moulding powder was supplied for links of the strongest plastic which could be obtained as it was obvious that the strength would be less than that of a chain of the same dimensions made in malleable iron. So far as experience has shown, with a service life now extending to over nine years, this chain has given entire satisfaction under the corrosive conditions encountered. The links were moulded by De la Rue Plastics, Ltd.

The pump impeller (Fig. 5) is an interesting example of precision moulding. First intended for pumping petrol, it was later applied to the pumping of acid. Moulded in Bakelite material, this impeller was designed to operate at a speed of 17,000 r.p.m., moving 250 gallons of petrol per hour at a pressure of 10 lb. per sq. in. Previous to the adoption of a plastic moulding, these impellers (which are in the form of a left-hand helix of 1-in. pitch, with each of three blades representing 270 degrees of the complete turn) had to be machined separately from a solid bar of metal, using a machine which had to be designed specially for such intricate work. As a Bakelite moulding the cost of production

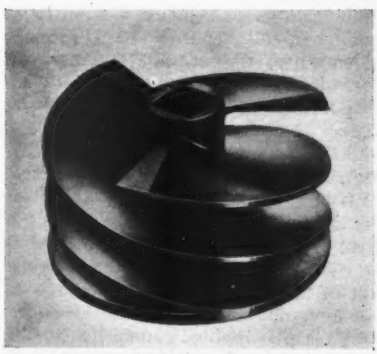


Fig. 5.—Impeller in the form of left-hand helix, 1⅜-in. diameter, to operate at 17,000 r.p.m., pumping 250 gallons of petrol per hour. Moulded in Bakelite by Merriott Mouldings, Ltd. (Bakelite, Ltd.)

was but a fraction of that originally obtaining, likewise time of production; moreover, the employment of plastic with its resistance against corrosive action greatly assisted in extending the use of these impellers for the pumping of liquids other than petrol. The moulding was carried out by Merriott Mouldings, Ltd., and was so perfect that when the speed of operation was so far increased for passing 600 gallons of petrol per hour, there was neither distortion nor any tendency for the impeller to seize in its casing. That this was a distinct achievement in precision moulding will be evident when further mentioned that the blade thickness of the impeller was only 0.04 in., and the overall diameter 1.625 in., with a tolerance of minus 0.004 in., and that the various diameters had to be concentric within plus or minus 0.001 in.

In the vacuum evaporation of mother liquors of soda manufacture as carried out in the U.S.S.R., the rate of corrosion varies with the changing composition of the liquor as evaporation proceeds, and there is marked difference between that in the gaseous phase and that shown by the solution, which normally contains ammonium chloride, carbonate, and sulphate, as well as sodium nitrate and sodium carbonate. A study of corrosion effects in this connection was carried out at the State Institute of Applied Chemistry at Leningrad, as reported by Professor Adjemyan at the second Conference on Corrosion held in Moscow in 1943. Evaporating at a temperature of 80 degrees C. under pressures of 170 to 350 mm., it was found that ammonium carbonate predominated at the commencement of evaporation, and that the alkaline liquor with pH value 8.0-9.0 had but slight corrosive action towards metal constructions for plant. With the dissociation of the carbonate, and formation of free ammonia and carbon dioxide, however, the pH declined rapidly to 1.5-2.0, and corrosion of metals correspondingly increased.

This corrosion was very marked in the case of iron, where loss in weight increased from 0.15 to 3.4 grams per sq. metre of exposed metal surface per hour, although as evaporation proceeded the loss (still high) actually declined with increasing salt concentration to about 1.5 grams per sq. metre. Under identical conditions chrome alloys exhibited only a slight loss in weight, but any advantage otherwise gained was offset by notable localized action. In the gaseous phase, at all stages of the process corrosion was many times greater than in the liquid phase, and all metals were affected in varying degree. As alternative, a non-metallic protective lining was suggested, and ultimately the use of asbestos bonded with polyvinyl resin was found to be eminently stable under the conditions obtaining.

There also appears to be a wide potential use for synthetic resin plant in counteracting corrosion in the oils and fats industry. Although oleaginous products from oil seeds or nuts should be completely neutral if the nuts are perfectly sound and ripe, as the glycerides of fatty acids—mostly oleic, stearic and palmitic —they can fairly easily be split with formation of free fatty acid. The latter reacts with the metal of processing plant and storage containers alike to form metallic soaps, especially in the case of iron, which in turn causes discoloration of the product. For example, in working up coconut oil-cake residues, there is a high iron content in the residual oil when unprotected iron is used as a plant construction material. This was emphasized in Vol. 47 of a series of progressive reports published in Germany during the war dealing with the production of oils and fats. Acid-resisting cements, such as Asplit A and F, incorporating phenol-formaldehyde resin, found useful application as a vessel lining in one aspect of this trouble.

Recognition of the usefulness of plastics as plant construction materials has come slowly. Among other industries, that of synthetic textiles has been most progressive. In the manufacture of rayon and related fibres, spinning pots, pot covers, bobbins, skein rods and gears had need to be resistant to either alkalis or acids, and likewise free from impart-

	Phenol-formaldehyde	Cellulose nitrate	Cellulose acetate	Polystyrene	Casein	Polyvinyl chloride	Urea-formaldehyde	Polymethyl mechacrylate
Weak acid	5	2	1	3	3	9	1	5
Strong acid	2	—	—	3	3	9	—	5
Weak alkali	—	2	1	3	2	9	1	5
Strong alkali	—	—	—	3	2	9	—	5
Alcohols	4	—	—	—	3	9	7	—
Ketones	7	—	—	—	3	—	7	—
Esters	7	—	—	—	3	—	7	—
Aromatic hydrocarbons	8	5	4	—	3	—	7	—
Aliphatic hydrocarbons	8	5	4	—	3	9	7	3
Mineral oils	8	5	9	4	3	9	7	9
Animal oils	9	5	9	4	3	9	7	9
Vegetable oils	9	5	9	4	3	9	7	9
(Number of samples)	(7)	(3)	(3)	(3)	(1)	(2)	(3)	(1)

This chart shows the relative evaluation of different plastics (assessed in points) as regards suitability for contact with specified classes of chemicals. It has been based on the degree of satisfaction obtained in experience (number of samples specified). The conclusions to be drawn are tentative, owing to the restricted amount of data available to the author.

It should be noted that the figure for urea-formaldehyde does not mean that it is quite unsuitable in presence of weak acids or weak alkalis.

ing a stain to the yarn. There have also been corrosion troubles from the splashing of spinning bath liquor. Generally this type of corrosion has been counteracted by the use of materials of the phenolic resin type, which can be moulded easily and cheaply and which proved mechanically strong to resist rough handling. Small parts of spinning pumps, and washing machines equipped with agitator mechanisms, have been made of Bakelite material or Bakelite laminated. Among other plant accessories made of Bakelite, there has been satisfactory experience ranging from soap shredders to nozzles for spraying acid or for use in cooling towers. In each case appropriate moulding material formulæ have been selected to provide mechanical strength, lightness in weight, resistance to temperature changes, and resistance to abrasion, apart from deterioration in the presence of chemical agencies.

For moulded parts the selection of the right material is vitally important. The choice of the plastic, of course, is governed mainly by the nature and concentration of chemicals making contact, as also by the maximum temperature to be attained. The newer phenolic moulding materials are considerably more resistant to chemical attack than older types. Phenol-formaldehyde resins are now available in grades which resist alkali up to 25 per cent. at 20 degrees C., and up to 10 per cent. at 100 degrees C. More than one grade is now said to be satisfactory for contact with 50 per cent. nitric acid at 50 degrees C. or for concentrated sulphuric acid at the same temperature, although even material such as Keebush is not normally recommended for use with strong oxidizing acids, such as nitric acid and 50 per cent. sulphuric acid, nor for strong caustic soda or caustic potash, sodium hypochlorite, acetone, amyl acetate, iodine, bromine, and such bases as aniline and pyridine. It is perhaps better to say that Keebush *is* attacked by oxidizing acids, strong alkalis, etc., although the extent of attack may not seriously preclude its employment.

That great advance has been made will

Fig. 6.—Absorption System with four towers each 3 ft. diameter x 7 ft. high, made of Keebush, connected by Keebush pipework and embodying Kestner - Saunders Keebush valves. (Kestner Evaporator and Engineering Co., Ltd.)

be evident on recalling the early days of non-metals as constructional materials for chemical plant, when hard rubber in use for pipes, valves, and tank linings, was commonly acceptable only up to a temperature of 50 degrees C., although below this point it proved quite satisfactory for contact with hydrochloric acid at all concentrations, strong alkalis, and sulphuric and hydrofluoric acid up to 50 per cent. strength, as also for such products as formaldehyde and furfural up to about 38 degrees C. Polyvinyl acetate, among other present-day materials, has very good resistance to chemical attack, especially at normal temperature. One plastic based on this resin is claimed not only resistant to the common industrial mineral acids, but also towards carbon tetrachloride, carbon disulphide, and formaldehyde, although its melting and softening temperature has prevented extensive use.

It was nearly 20 years back that synthetic resins first found use as a coating for filter-press plates handling oxalic acid ("Chem. Met. Eng.," 1928, 35/568). Plates and frames made wholly of phenolic resins are now finding valuable use for contact with dyestuffs after salting-out; made with polyvinyl resins they are being recommended in contact with solutions containing sodium hypochlorite. A surface coating of phenolic resin has been successfully extended to dryer trays made of aluminium, especially for exposure to sulphuric acid and hydrochloric acid, as also for resisting acetic acid fumes. Agitator paddles moulded in Bakelite have proved to be unimpaired after intermittent immersion in copper and nickel plating solutions, changing from one solution to the other over a period of many months. Laminated synthetic resin material with a paper base made in form of pipes has proved suitable for handling hot brine ("Ind. Eng. Chem.," 1935, 27/1284). Donald ("Chem. and Ind.," 1935, 54/256) has referred to the need for avoiding resin of low phenol ratio when high chemical resistance is expected.

The resin-bonded laminated wood made by Moulded Components (Jablo), Ltd., under the name of Jabroc, is finding employment in the dyeing, tanning, battery making, and plating industries. Insul-Jabroc, which increases in volume by only 2 per cent. after being immersed in water for seven days, can conveniently be used for the construction of bench tops, fume cupboards, and in similar situations in the chemical laboratory; also for the blades of fans.

Phenolic resin equipment of the original Haveg type, now represented in England by Keebush, can be supplied in one-piece moulded constructions ranging in size from a quart dipping pot to a 5,000-gallon tank. Very large equipment is made by assembling flanged units to provide any desired shape and size. There is practically no limit to the size of plant which can be made by this sectional construction method. Other applications include pipes, valves, absorbing and scrubbing towers, agitators and stirrers, crystallizing vats, drying trays, equipment for evaporating and concentrating, fume ducts, fan housings and fan blades, and equipment for dyeing.

Cylindrical tanks are moulded in one piece in diameters up to 9 ft., with depth up to 10 ft., and are seamless and jointless. When deeper units are required they are constructed in sections, which are bolted together by convenient flanges. To give greater strength, and likewise to reduce the actual amount of synthetic resin employed, tanks of large dimensions are provided with reinforcement, either in form of steel bands or external wooden staves with steel hoops. The cost of fabrication for such tanks is reduced to the minimum by using a number of standard moulds from 1 ft. to 9 ft. diameter and corresponding depths. Rectangular tanks in one piece are made up to 10 ft. long, length, width and depth having increments of 6 ins. Larger tanks up to 60 ft. are made in sections.

Fig. 6 shows a complete absorption system made of Keebush. The four towers are each 3 ft. diameter by 7 ft. high, and are connected by pipework of the same material, embodying Kestner-Sanders valves also made of Keebush. Each tower is capable of withstanding a working pressure of 5 to 15 lb. per sq. in., and the complete assembly is unaffected by the sulphur dioxide in the liquor circulated. Regarding fans for corrosive gases, while the fan body and impeller are made in solid material, the impeller shaft is mild steel covered with the plastic concerned, and the complete assembly is bolted within an open cast-iron frame. The light weight of the resin material enables such a fan to be made far smaller than commonly, and to absorb less power for a given capacity by comparison with fans made of other materials.

In connection with crystallizing vats and drying trays, there are two points in particular which commend the use of plastics. Crystallizing vats do not suffer deterioration when crystallizations are

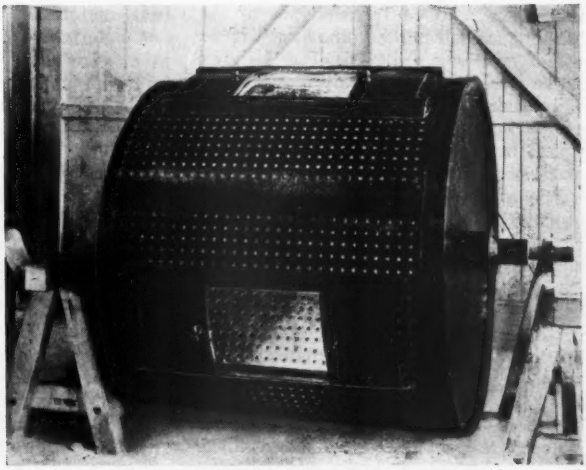


Fig. 7. — Keebush drum for the dyeing of felt hoods (hat manufacture), in use provided with timber framework and stand. (Kestner Evaporator and Engineering Co., Ltd.)

exothermic, for reason that the plastic withstands sudden changes of temperature. Drying trays made of plastic are not only light in weight, they are especially suitable for the drying of colours where a pure shade is liable to be affected by contact with metal, or where a sensitive product is likely to incur the risk of explosion when touching metal. Owing to the homogeneous structure of the plastic there is absolutely no risk of contamination taking place as the result of a damaged tray surface, which cannot be claimed for any metal tray with a mere surface protection of acid-resisting varnish, even when the varnish is a recognized plastic. The relatively low heat conductivity of the plastic is also important; this promotes a uniform rate of drying and avoids any part of the batch becoming overheated.

Used for dyeing equipment, such a material as Keebush enables all shades of colour to be produced in unequalled degree of purity, especially as regards brilliance, which for certain vivid colours is so easily impaired by contact with a metal surface. Additionally, the smooth, seamless surface does not absorb dyes; the cleaning of the vat is easily done by hosing and wiping; there is never the need to boil out residual dye. This enables dark and light dyeings to follow in quick succession, with entire avoidance of the bleeding, which is a common experience when wood vats are used. Fig. 7 shows a hat-dyeing drum made of Keebush. This drum is loaded with 120 lb. weight of felt hoods, and is then rotated at 12 r.p.m. in a sulphuric acid dyeing solution at 80 degrees C.

Phenol-formaldehyde resin in form of mouldings and as laminated material are both generally satisfactory for continuous use at temperatures up to 120 degrees C., with the possibility of reaching 150 degrees C. occasionally. Above these temperatures the material is liable to become brittle. When the moulded material contains a cellulose filler it begins to blister at 160-170 degrees C., which appears to be the limiting temperature at which these materials can be used. Asbestos-filled mouldings are more satisfactory for heat resistance than are cellulose-filled grades, and do not commonly show blistering until a temperature of 210 degrees C. is reached, sometimes not below 250 degrees C. Laminated sheet made from phenolic resins with a paper base should be completely resistant to a wide range of chemicals up to a temperature of 100-120 degrees C., including such solutions as 15 per cent. hydrochloric acid, 15 per cent. sulphuric acid, and 10 per cent. caustic soda.

Summarizing briefly the employment of plastics for the construction of industrial plant in situations where the corrosive influence of chemicals is likely to be faced, it may be suggested that these materials fall into six groups:

1. Pure synthetic resins without filler, moulded into a desired shape by pressure and heat, such as sight glasses of clear polymethyl methacrylate.

2. Resins incorporating suitable fillers, which acquire the desired shape by pressure or injection moulding and application of heat, such as pump impellers made of phenolic resins.

3. Resins in which asbestos or other mineral fillers are incorporated, yielding a material sufficiently stiff to be self-supporting, and which can be shaped by hand or otherwise and then hardened by heat treatment.

4. Resins impregnating paper, fabric, asbestos or wood in sheet form, rolled or built into laminated sheets, which may be pressed and heated to produce a tough product, from which gear wheels, etc., are cut.

5. Resins in suitable solvents giving protective varnishes, or otherwise utilized to provide a lining for a metal vessel by controlled evaporation of the solvent, subsequently heated or stoved.

6. Thermoplastic resin in sheet form cut to shape for the walls of a vessel, to which it is secured by stainless-steel screws (in absence of satisfactory adhesive), the countersunk screw holes being sealed with plugs of plastic, as application of polyvinyl chloride for a corrosion-resisting lining to plant.

LETTERS TO THE EDITOR

Plasticizer for Cellulose Acetate

Sir,—We wish to obtain a suitable plasticizer for cellulose acetate sheet or granules which either have little plasticizer content, or having been kept in stock for a couple of years have lost their plasticizer. We should also be glad to know by what method we can impregnate this material with plasticizer.

We are making reinforced sides for spectacle frames, using flash moulds by the compression method.

CAMDEN OPTICAL CO., LTD.
Crowthorne, Berks.

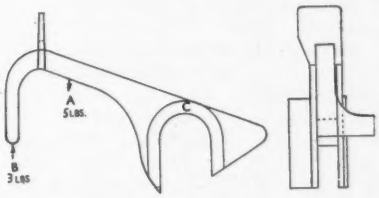
[EDITOR'S NOTE.—Since it seems obvious that the stock, which has hardened by loss of plasticizer, is small in quantity, we strongly advise that no attempt be made to incorporate the plasticizer in the acetate. The process requires considerable experience of masticating plastics on rollers and similar mixing plant, and satisfactory results are not always obtained on a small laboratory or pilot plant, which, however, is normally readily available. Without wishing to prevent experimentation on the reader's part, we stress that it is not an economic proposition on a small scale, and advise return to the makers. Dibutyl phthalate, tri-cresyl phosphate and other well-known plasticizers are obtainable from such concerns as British Industrial Solvents, Ltd., 21, St. James's Square, S.W.1, A. Boake Roberts and Co., Ltd., Stratford, E.15, and Howards and Sons, Ltd., Ilford, Essex.]

Carbon Brush Holder for Motors

Sir,—We are developing a new-type carbon brush holder for use on our D.C. machines, and wish to investigate the possibility of using plastics for the brush arms and the main bearing pins.

The twin brush arms apply a maximum pressure of approximately 3 lb. on to the top of two carbon brushes by means of torsion springs acting at points "A." Each spring would exert a pull of 5 lb. downwards, 3 lb. being taken by the brush at "B," and the balance on the bearing, which would be situated inside "C."

The pivot pin carries both brush arms. A slot in the pin takes the inner ends of clock-type torsion springs, and two other slots take a forked lever, which applies a torque to the springs of 14 lb./in. We are at present experimenting with a view



to eliminating one of the two slots to cheapen production.

The gear would have to work in temperatures varying from 32 degrees F. to 250 degrees F. maximum, and under these conditions the components must neither soften nor distort. The mouldings are to be self-extinguishing after severe conditions, such as flash-overs. Further, although the forces normally acting are comparatively small, the parts, especially the brush arms, must be capable of withstanding fairly rough usage, as they will be installed on shipboard.

We should be grateful for suggestions regarding any modifications to facilitate production and reduce costs, and the names of firms with facilities available for producing approximately 3,000 of each piece per year.

W. H. ALLEN, SONS AND CO., LTD.
Bedford.

"Perspex" Cigarette Cases

Sir,—We are anxious to get in touch with the manufacturers of "Perspex" cigarette cases, with a view to exporting to Australia.

WILLIS AND SONS PROPRIETARY, LTD.
London.

[EDITOR'S NOTE.—Thermo-Plastics, Ltd., High Street South, Dunstable, Beds; Wokingham Plastics, Ltd., Wokingham, Berks; Plastilume Products, Ltd., Staines Road, High Wycombe, Bucks.]

Spray Gun

Sir,—In the July, 1945, issue of your journal Mr. E. E. Halls, in the section of his paper, "Plastic-applied 'Coatings' by Spray and Dip," refers to the Aerasprav Manufacturing Co., Ltd., as manufacturers of a spray gun for the production of "flock" surfaces. We would be obliged for the address of this firm.

J. H. BRIERLEY (GRAMOPHONES AND RECORDINGS), LTD.

Liverpool, 2.

[EDITOR'S NOTE.—Aerasprav Manufacturing Co., Ltd., 1, Victoria Street, London, S.W.1.]

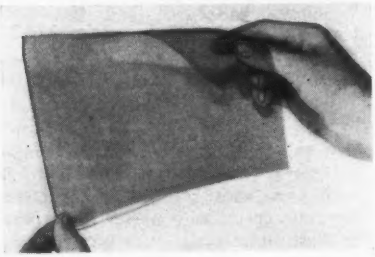
Mosquito Screens

Sir,—Clients of ours in Southern Rhodesia have sent us a sample of an American plastic screen. This screen is made up of wires to make a mesh, and is eminently suitable for mosquito screening. Our friends feel that this material has advantages over steel wire netting, for instance, being rust-proof, non-corrosive and colour-fast. Our friends would prefer to obtain their requirements from the U.K.

FOWLIE, REID AND WILLS, LTD.

London, E.C.1.

[EDITOR'S NOTE.—We think the sample of mosquito screening which you sent is made by the Dow Chemical Co., Midland, Michigan, U.S.A., in which country it has been widely publicized. The material is



polyvinylidene chloride and, we think, admirable for the purpose. Unfortunately in England we have not turned over sufficiently to make the material, which, in any case, would merely be of export interest. In the Southern States of the U.S.A., apart from neighbouring Mexico, there is, of course, a huge demand. In this country some experimental Nylon screenings have been made, but they have been somewhat expensive and, in addition, the supply position does not yet permit of large-scale production. We think it might be advisable for you to get into touch with British Nylon Spinners, Ltd., 72, Lockhurst Lane, Coventry, or Imperial Chemical Industries, Ltd., Plastics Division, Black Fan Road, Welwyn Garden City, Herts, who could tell you the present situation.]

Plastic Coating

Sir,—In your April publication, under the head "General Engineering," we note with interest a reference to "Thermodip" easily stripped plastic coating as protection against corrosion, etc.

We are very interested in a product of this type and should appreciate the address of Eronel Industries.

HUGH RUSSEL AND SONS, LTD.

Montreal 3, Canada.

[EDITOR'S NOTE.—The address of Eronel Industries is 5714, West Pico Boulevard, Los Angeles 35, U.S.A. While we have no information regarding the composition of the raw material, it is stated that the dipping is carried out at temperatures between 280 degrees to 325 degrees F. It will be remembered (see "Plastics," 1945, p. 63) that, in our description of "Strip-coat" the ethyl cellulose composition made by Dow Chemicals for the same purpose, the optimum temperatures were given as 325 degrees to 375 degrees F., so that, so far as this is important, Thermodip may be considered an advantage. In passing, it should be remembered that neither the idea nor the process is new, since during the 1914-1918 war we in this country were dipping valuable objects liable to corrosion in a molten mixture consisting, we believe, of a cellulose acetate base made in Spondon.]

Transparent Containers

Sir,—We have seen the letter of Grosvenor House (Park Lane), Ltd., inquiring for transparent flower boxes. We are manufacturers of rigid, plastic, transparent containers for the packing of all kinds of goods, including flower boxes.

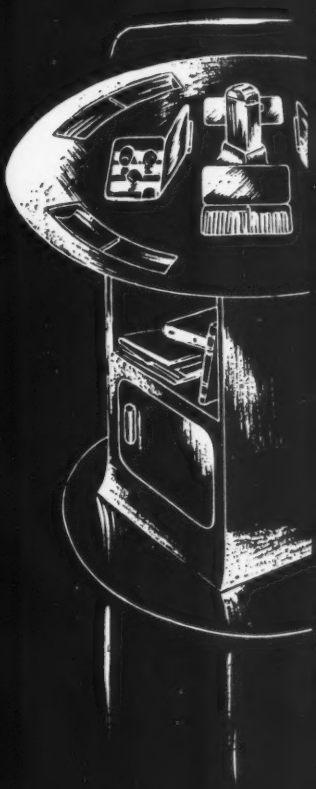
TRANSPARENT PACKINGS MANUFACTURING CO., LTD.

14, Westland Place, London, N.1.

SMOKERS PLASTICS

UNIVERSAL SMOKER'S TABLE

A MOULDED TABLE TOP WITH INDENTS FOR CIGARETTE BOX, CIGAR BOX, TOBACCO JAR AND ASHTRAYS FROM PHENOLIC OR COMPOSITION MATERIAL. NECESSARY FITMENTS FOR MOULDED LIGHTER, TRANSPARENT LIDS, SUITABLY FIXED BOOKSHELVES AND CABINET GIVE ADDITIONAL USEFULNESS



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ORIGINAL DRAWINGS AND SPECIFICATIONS FROM THE PLASTIC RESEARCH LABORA

PLASTIC

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ESEARCH LABORATORIES OF GEORGE B. E. SCHUELER, CONSULTANT.

CIGARETTE CASES

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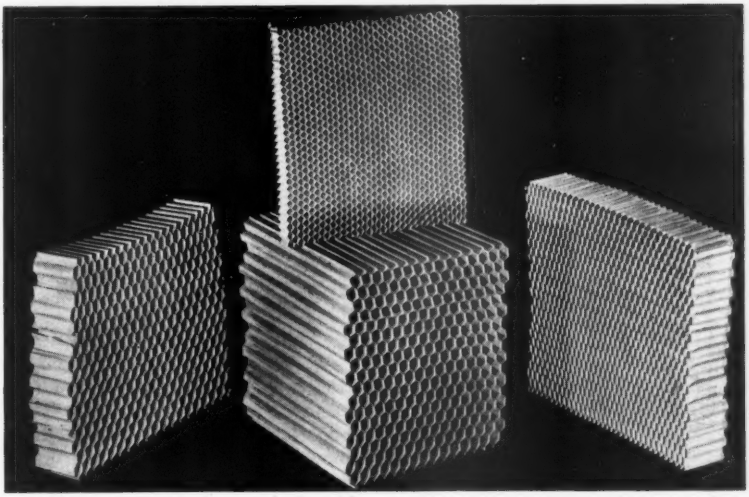


DUFAYLITE

A New Low-density High-strength Material, Developed During the War, Now Appears on the Market for Peace-time Constructional Purposes

THE search for light, yet strong, materials is an old one, but for obvious reasons reached its apogee during the late war. The outstanding properties of balsa wood have always made this natural product of value and, indeed, it became one of the most important elements in the construction of the famous "Mosquito," the fastest aircraft of its time. Its use, however, is obviously limited and for most purposes a material of greater flexibility in its physical and mechanical properties is desired.

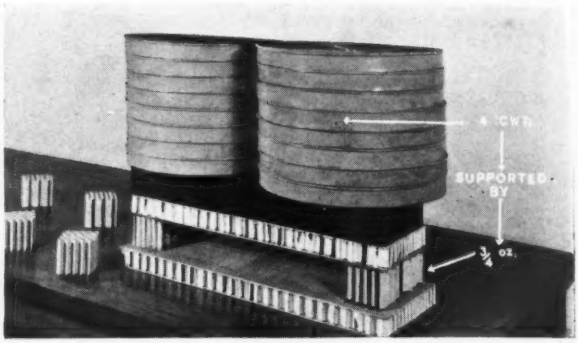
Long before the war "Onazote," an expanded rubber faced with plywood or other sheet to form a rigid structure, was well known. The same producing company placed on the market during the war similar light, high-strength materials, such as expanded phenolic resin, expanded polyvinyl compounds, etc. In another category we find the outstanding "Holoplast," with its construction based on the desirable I-shaped form, cutting its own special swathe in industry.

In still another class we find the material known as Dufaylite, which opens up still newer and wider fields of application, and which is the subject of the present note.

About the beginning of 1943, Dufay-

Low Density Materials (Comparative Weights)

	Lb. per cu. ft.	Sp. gr.
Dufaylite "A"	1.88	0.030
Dufaylite "B"	1.31	0.021
Dufaylite "C"	0.94	0.015
Stringer Board	10	0.16
Balsalite	5	0.08
Indian Reed	3.45	0.06
Expanded Perspex	15	0.24
Expanded Hard Rubber	4–12	0.06–0.19
Expanded Formvar	8–15	0.13–0.24
Balsa Wood	5	0.08
U.S.A. Glass Fibre	8	0.13
U.S.A. Foamed Phenol Formaldehyde	6.5	0.10
German Polystol	5.8	0.09
German Holig	16.5	0.26
Slab Cork	6	0.09



Simple demonstration of the strength of Dufaylite. The four small cubes, acting as supports, weigh ¾ oz., the total area exposed to pressure being 16 sq. ins.

Chromex, Ltd., which name is deservedly famous in the realm of pure physics as applied to the production of special film for colour work, colour filters, X-ray cameras, etc., was actively engaged in the development of a new technique for the manufacture of double-curvature paper-jettison petrol tanks for the " Mosquito."

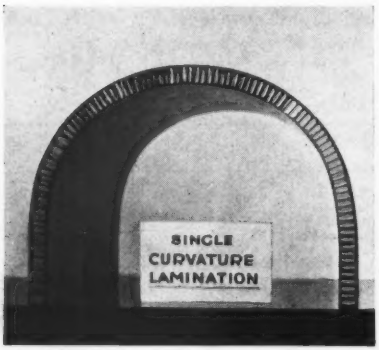
After producing the 50-gallon tank, the 100-gallon tank and, subsequently, that of 200 gallons capacity went into production, considerably increasing the range of this machine.

At the same time, as a result of intensive research, the company succeeded in evolving a new technique for the construction of " Radomes " in glass fibre cloth laminated with resins.

Whilst carrying out this high-priority work to fill urgent Government requirements, it became obvious that it was of importance to find a material which should be lighter, and yet be as strong, as the heavier of the low-density materials already in use.

In these circumstances, and under the auspices of the Royal Aircraft Establishment at Farnborough, " Dufaylite " was developed, perfected and patented by Dufay-Chromex, Ltd.

" Dufaylite " is the most advanced expanded material now in existence. Consisting of a multitude of resinated paper cells bonded between two thin skins of practically any material, such as plywood, aluminium, plastic, etc., it forms a



Application of Dufaylite to single curvature construction. Multi-curvature is also readily obtained.

new laminate which combines featherweight with high strength.

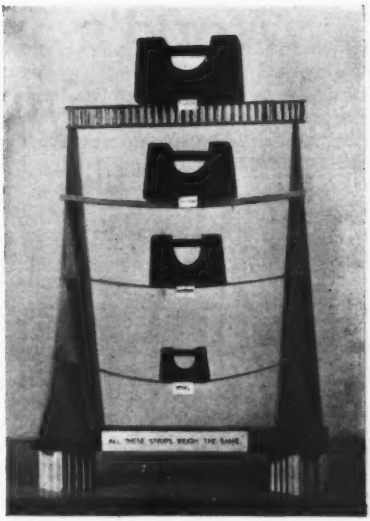
The construction of the basic cellular, or "honeycomb," material is at once one of the most ingenious and economically sound we have yet encountered. It is fabricated from Kraft paper, which has been impregnated with synthetic resin (an I.C.I. phenolic resin is employed). Layers of this treated sheet are then subjected to a special gluing technique which results, on mechanical stretching or pulling, in the hexagonal cellular forms seen in the photograph at the head of this article.

The strength of this basic material itself is extremely high and a "slab" 2 or 3 ins. thick will easily bear the weight of a man standing on it, the pressure being directed against the vertical channels. With the pressure in the opposite direction, that is parallel with these channels, the structure exhibits great elasticity, making possible the construction of double or more curvature shapes.

Normally, as already indicated, the "slabs," which can be of any thickness, are faced with plywood or metal sheet again bonded with synthetic resin and suitably cured, resulting in a form which is not only of outstanding lightness and strength, but one which is also dimensionally stable under the effect of moisture or water.

Obviously a great variety of qualities can be obtained by altering the thickness of the paper and the percentage content of the resin (normally the impregnation leaves 25 per cent. in the paper). Changes are also brought about by altering the size of the hexagonal cell. In all cases, however, the fundamental strength of Dufaylite resides in a combination of factors which relate to the distribution of stresses inherent in the special cellular design. Tensile strength, compression strength, shear and fatigue strengths are all of a high order, the exact dimensions of which are now under examination and will eventually be disclosed.

So far as present progress is concerned, of greatest interest are the industrial outlets for Dufaylite. Among these are the following. For aircraft: flooring, panelling, fixtures and fittings, furniture and doors. For house construction: doors partitions, flooring and shelves. Obviously, too, there are a host of other possible applications, such as Pullman-car partitions, railway-carriage panelling and ceilings, motorbus and caravan bodies, featherweight furniture shelves, trunks and cases. Some of the best-known British aircraft manufacturers have already specified "Dufaylite" for flooring, bulkheads, doors and tables. The material will also find adequate employment in the fields of shock-absorption, acoustics and thermal insulation.



Demonstration of resistance of Dufaylite to bending. Dufaylite loaded with 14 lb.; plywood, 7 lb.; aluminium, 4 lb.; steel strip, 1 lb. All strips are of the same weight. The complete assembly is supported upon four 2-inch cubes of Dufaylite weighing ¾-oz.

An interesting collection of objects made from Dufaylite were shown us recently by Mr. D. Dalponte, managing director of Dufay-Chromex, Ltd., at the offices in Cockspur Street, London, S.W.1.

World's Industry Employs Plastics

GENERAL ENGINEERING

Abstracts of papers by W. J. Connelly on **low-pressure moulded laminates** using phenol - formaldehyde, amines and thermo-setting ester resins, presented at the Society of the Plastics Industry, and by R. N. Freres on **Friction Welding** of plastics, presented at the Canadian Section meeting of the same society, have been published in " Product Engineering," 1946/**17**/404. Tungsten carbide tipped **hobs for generating teeth in abrasive phenolics** are discussed in " Industrial Plastics " (Ohio), 1946/May/16. The initial cost of the tungsten carbide hob is said to be about three times that of high-speed steel hobs, but production is 40 times the volume previously obtained. Laboratory tests on the physical properties of a newly developed **cellular laminate** are given by C. A. Scogland in condensed form. The laminates are of paper, cotton, fabric, glass, textiles, aluminium, steel and plywood, using Bakelite resin 16320 as binder, pressure varying between 164 lb./sq. in. to 325 lb./sq in.; curing time 10 mins. at 300 degrees F. Data given on flexural strength, compressive strength, impact strength and heat transmission characteristics. (" Product Engineering," 1946/**17**/394). An **airtight plastic covering** for the **protection of machines** is said to provide surfaces with a tough non-inflammable anti-corrosion film of long durability. The material has a life of 20 years, resists a tensile pull of 2,000 lb./sq. in., and is flexible. The properties are maintained through a temperature range of 40 degrees F. below zero to 200 degrees F. (" Products Finishing," 1946/**10**/114.) Long-range research in **plastics products problems** has been inaugurated at the Massachusetts Institute of Technology, sponsored by the Plastic Materials Manufacturers Association and the leading American producers. (" Product Engineering," 1946/**17**/419.) Before applying the **rustproof plastic coating** Durakote by means of an air-brush, an etched iron and steel surface which is absolutely clean is obtained by abrasive grit blasting; used brass cylinders for wells, etc., may therefore be replaced. (" Products Finishing," 1946/**10**/64.) Future possibilities in **protective coatings** from plastics are enumerated in a short article by Dr. A. G. Gray. (" Products Finishing," 1946/**10**/50.) It is suggested fixing **laminated plastic plates** by means of pins of the same material to the guides of machine tools, with the laminations at right-angles to the bearing surfaces. Such bearings have been used in continuous day and night service for over two years on a heavy-duty planer with a normal return speed of 380 ft. per min. (" Machine Tool Blue Book," 1946/**42**/334.) A brief article on **laminated materials** by Dr. V. E. Yarsley appears in " The Times, Trade and Engineering," 1946/June/36. There is reference to railway coaches and boats, including a highly specialized type of light racing skiff normally carvel-built in cedar wood, now replaced by a hull of 1/64-in. plywood to which the ribs are cemented. Technical data on Teflon, a new **acid-resistant heat-stable plastic** have been published. Applications of this **tetrafluorethylene** resin include flared tubing, threaded pipe, cylinders, co-axial cable spacers, gaskets, tape, plug cocks and valve stem packing. (" Product Engineering," 1946/**17**/418.) **Costly tools** and metal components are best **protected by plastic coatings.** (" Tool and Die Journ.," 1946/**12**/93.) Different

ways of **moulding plastics** are described in an American article ("Scientific American," 1946/**174**/261); low-pressure moulding is recommended in many cases. **Mould costs** can be reduced by centrifugally casting plastics. ("Production Engineering and Management," 1946/**17**/103.) **Plastic engine coating** is discussed in "Materials and Methods," 1946/**23**/1,025. A clear, hard coating of plastic is placed on the inside of a water-jacket and after baking becomes so durable that it cannot be removed by caustic soda; this material is being made by Ault and Wiborg Corporation, Ohio.

CHEMICAL

A general survey of **vinyl plastics** by G. E. Henry differentiates between five members of the group: vinyl chloride acetate, vinyl acetate, vinyl butyrals, vinyl chloride, and vinylidene chloride polymers. There are at least eight prominent companies that make vinyl plastics. ("Purchasing," 1946/**20**/115, abstracted in "Materials and Methods," 1946/**23**/1364, 1366). The **phenomenon of gelation,** which affects thermoplastics and thermosetting plastics alike, is discussed in "India Rubber Journal," 1946/June 8/3, and June 15/3. Correct gelation is said to be necessary to ensure optimum properties, especially as regards physical strength of P.V.C. and phenolic resins. The term "gelling" is considered most satisfactory to describe the process when P.V.C. powder, mixed with plasticizer, is moulded under the action of heat and pressure. Carried in a volatile vehicle **modified vinyl polymers** form extremely tough, elastic impervious films that stick with high adhesion, but can be stripped off in sheets. The so-called liquid envelope is used for protecting polished sheet in transit. ("Products Finishing," 1946/**10**/102.) The first of a series of articles on developments in the field of **testing procedures** for the evaluation of natural and **synthetic rubbers** and **plastic elastomers,** as sponsored by the Bureau of Ships, U.S. Navy Department, appears in "Rubber Age" (New York), 1946/May/173. The present article deals with adhesive test methods, various types of apparatus used being illustrated. Two **new plasticizers** have been developed by the Dow Laboratories ("Scientific American," 1946/**174**/271); the same laboratory has also developed light plastics which will float on water and retain flexibility (ibid. 267). The **production of nylon** is described in an abstract from "Chem. and Met. Eng."; the safety of **nylon tinting** is mentioned. ("McGraw-Hill Digest," 1946/**1**/4, 25.) **New materials and techniques** which have tended to broaden the application of plastics are discussed in "Product Engineering," 1946/**17**/297; this review deals with allyl resins, modified styrenes, cellulose propionate, silicone materials, plastic-coated metal tubing, melamine moulding compounds, polythylene and nylon.

TEXTILES

Various new uses of plastic materials are discussed in an article in "Business Week" ("McGraw-Hill Digest," 1946/**1**/1); this article deals especially with the **reinforcing of woven fabrics,** paper or fibres. So-called **plastic furs** are to be manufactured at Montreal, Canada, by a process in which ordinary tanned and sheared sheepskins, with wool varying from ½ to 1¾ ins. in length, are first subjected to the action of gaseous hydrogen chloride to change the keratin molecule, which is the basic component of hair. Subsequent hydrolysis separates the molecular chains into two kinds (amino and imino), following which formaldehyde is applied to the softened hair to cause "molecular welding." Cresol is used for final treatment.

MISCELLANEOUS

The **contact mechanism** of an electric **citrus fruit counter** uses transparent plastic and die cast aluminium-alloy parts. The paddle is of plastic having two serrated bronze bushings at the hinge pin (" Product Engineering," 1946/**17**/366). The United States Rubber Co. announces rubber-covered **potato baskets** to safeguard potatoes against bruising (" Product Engineering," 1946/**17**/371. A **drawing and measuring instrument** in new form is made of transparent yellow Tenite; it is made in two parts, pivoted together, and performs eight different jobs: square, dividers, protractor, triangle, ruler, French curve, or mitre (" Instruments," 1946/**19**/281). An improvement in the quality of **finishes on refrigerators** and **washing machines** is obtained by a non-drying phthalic alkyd in conjunction with urea-formaldehyde resins or nitrocellulose, to produce fast-baking finishes at high temperature (" Products Finishing," 1946/**10**/106). **Slide rules** said to possess remarkable dimensional stability have been produced by C. Bruning Co., Chicago, 41; the precision graduations are said to be unaffected by temperature change (" Machine Tool Blue Book," 1946/**42**/306). Non-chipping, non-yellowing **plastic enamel for refrigerators** and **kitchen appliances,** and a moisture-proof coating for packaging and for shipping machine parts, are announced by Naugatuck Chemical Div., United States Rubber Co. (" Products Finishing," 1946/**10**/111). The D.C. Cooper Co., Chicago, 5, announces an oil-jacketed tank for **heating ethyl-cellulose** compounds in which precision tools are dipped for protection against rust, corrosion and breakage (" Products Finishing," 1946/**10**/93). **Plastic seals** which are water and heat resistant are being made by the General Electric Co.; the American Cyanamid Co. are manufacturing heavy-duty plastics for **household appliances;** Little-Fuse, Inc., are marketing a plastic **night-light** made of **styron,** which can be plugged into the ordinary light socket; bristles of **vinylite monofilaments** are the latest development in the brush field (" Scientific American," 1946/**174**/263.) **Troweling compounds** made of plastics can be moulded to close tolerances (" Scientific American," 1946/**174**/279). Du Bois Plastic Products are manufacturing nylon **drinking tumblers** (" Scientific American," 1946/**174**/278). The place of plastics in future **film manufacture** and sensitization, with base and emulsion keyed together in negatives, is discussed in " Kinematograph Weekly," 1946/June 6/xxi. **Synthetic rubber hose,** reinforced with a fibre-glass inner braid, has been developed by De Vilbiss Co. for hot plastic paint (" Product Engineering," 1946/**17**/283). **Tennis-racket string** of twisted multifilament nylon yarn provided with a new coating is the subject of a United States patent assigned to the Du Pont Nemours Co. It is a corded affair with each strand of the cord consisting of individual filament of polyhexamethylene adipamide twisted together. The smooth coating constitutes about 30 per cent.

SOURCES OF REFERENCE.

We wish to remind readers that the sources of reference from which these pages are compiled are not, in general, retained in this office. We cannot, therefore, undertake to supply such originals. Nevertheless, most of the foreign journals referred to are available in the Patent Office Library (Southampton Buildings, Chancery Lane, W.C.2) and in the Science Library (South Kensington). Photo-duplicated copies of articles may be obtained from the Photostat Dept. of the Patent Office.

PLASTIC BONDING OF LIGHT METALS

By E. Preiswerk and A. von Zeerleder*

FOR the assembly of light-metal components, riveting, brazing, welding and seaming are commonly applied with satisfactory results. Simplification and better properties, however, are frequently desired from the standpoints of production and the performance of the completed structure. New problems, such as corrosion-resistant junctions between aluminium with other metals such as iron and steel, or strong joints between light metal and plastic, glass and ceramics also arise.

The use of cementing techniques is well established but, even with plastic adhesives, is no cure for all ills, although, correctly applied, creates new possibilities.

The quality of a plastic bond depends mainly on two factors:—(1) Mechanical strength of the bond, at the resin-metal interface; (2) mechanical strength of the resin.

The use of plastic bonding will, in practice, be determined by its strength under static and dynamic loads over a wide temperature range, and by its resistance to atmospheric influences, water, electrolytes, organic solvents, etc. Further considerations are the resistance of the bond to ageing, its ease of production, and its relative cost. Freedom from smell, taste, or toxicity when used for packaging, and the resistance of the resin electrolyte in the anodic oxidation of light metals, may also be of importance.

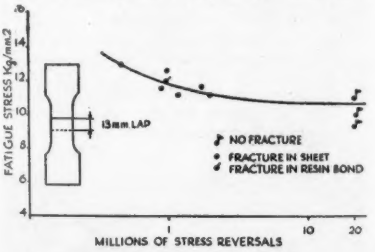


Fig. 1.—Fatigue strength of Araldit-bonded Avional D sheet 1 mm. thickness with 13 mm. lap at join.

In Araldit CIBA has been developed a medium to meet these requirements. It is available in the form of powder and bars, which, at a temperature of 40 degrees C., become doughlike, and at 80-100 degrees C. may be brushed on, whilst at about 120 degrees become thin fluid. In use, the plastic is brushed on the surfaces to be joined, these being already preheated to about 100 degrees; in many cases it may be just sprinkled on. By heating the parts to be bonded to temperatures between 120 and 220 degrees C. for 5 to 120 mins. (according to the type of plastic), the resin hardens without application of pressure and adheres thoroughly to the metal surface.

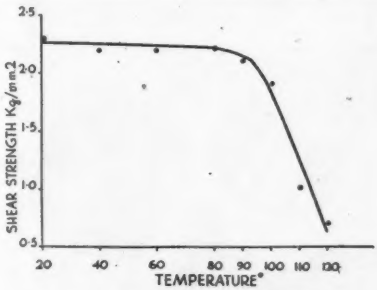


Fig. 2.—Hot strength of Araldit bond.

The eliminating of any need for pressure is very important; it is, of course, useful to hold the components in position during the hardening operation in order to avoid any slip or distortion. Owing to its fluidity, the resin can penetrate by capillary action.

With light metals, no particular pre-treatment of the metal surface is necessary, other than dusting and degreasing. Roughening of the surface, anodic oxidation or similar processes have no special influence on the strength of the bond. It is, however, of importance that the resin is applied in one operation. As the resin is fluid at elevated temperatures, no solvent is necessary, and during the hardening process no gases are evolved.

The quality of the bond obtained with

* Abstracted from "Schweizer Archiv," 1946/12/113.

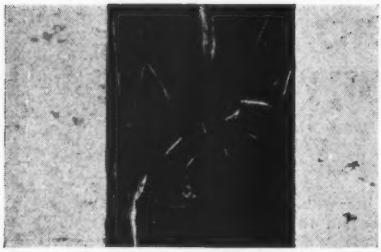


Fig. 3.—Cross-section of Araldit-Anticorodal bond. Thickness of resin layer is 0.1-0.2 mm.; the inclusions in the resin are aluminium bronze. (Equivalent magnification in reproduction equals × 173.)

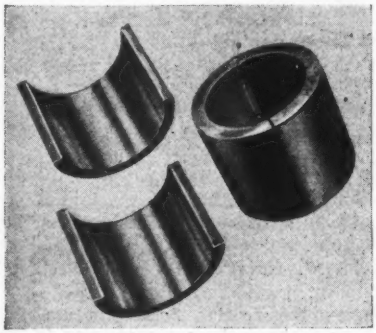


Fig. 4.—Two bearing brasses temporarily bonded with Araldit for purposes of finish machining.

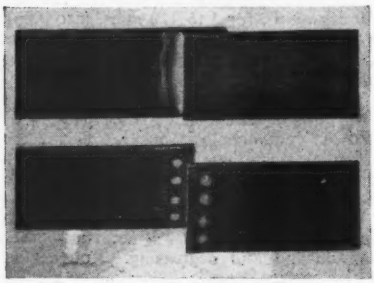


Fig. 5.—Comparison between the shear strength of an Araldit bond and a similar riveted joint. The material is in both cases fully heat treated Anticorodal B, 25 mm. wide and 1.5 mm. thick, join having a 12 mm. lap. The riveted join is of the single-row type with rivets in heat treated Anticorodal N 3 mm. diam.

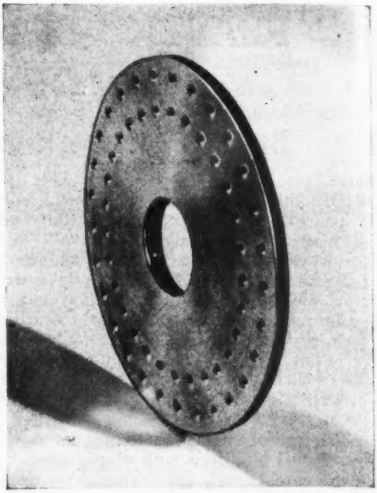


Fig. 6.—Light-metal plate bonded to a plastic moulding by means of Araldit.

Fig. 7.—Avional tubes, bonded with Araldit after test (see Table 2). With a join of the type and dimensions adopted here, a shear stress of 1.8-1.9 Kg./mm.^{2} is reached by the time the elastic limit of the metal itself has been exceeded The light areas on the tubes indicate where permanent extension has occurred.

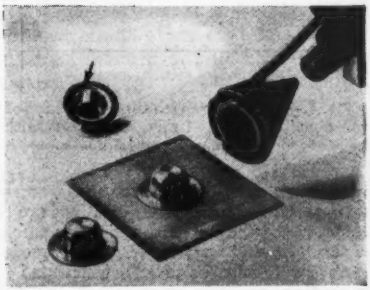


Fig. 8.—Araldit bonding of a light-metal cover. At the right of the illustration may be seen the special torch used for curing the resin.

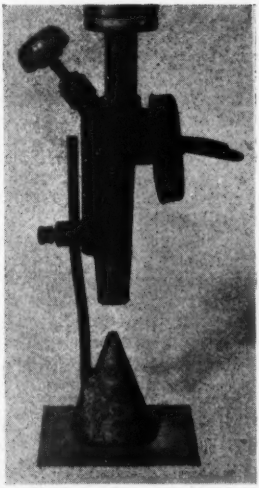


Fig. 9.—Assembly with Araldit bond in process of curing, using the special torch already shown in part in Fig. 8. The operation takes about 60 secs.

Fig. 10.—Assembly in light alloy showing Araldit-bonded lap joints (arrowed). In this case the resin was applied between the joints in powdered form, and on warming the assembly, flowed without difficulty between contacting faces.

Fig. 11.—An aluminium vessel with a flanged and rolled-over edge to guard against penetration of moisture. This part of the component has been sealed with Araldit as indicated by the arrow.

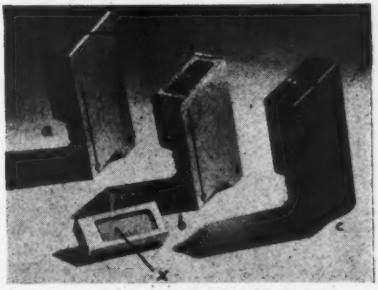


Fig. 12.—Assembling the base (x) of a cigarette lighter in light alloy by means of Araldit. In *a* and *b* the base is shown in position, whilst in *c* the lighter is pictured in its finished form anodically oxidized and dyed.

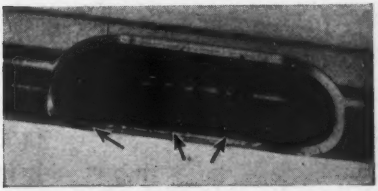


Fig. 13.—Enlarged sectional view of Araldit bonded joint between light-alloy tubes. The arrows indicate the position of the joint.

Table 1.—Relationship between Shear Strength, Sheet Thickness and Width of Lap. Specimen—25 mm. wide. Anticoroda 2B Strip; Bonded with Araldit, cured at 200°C. for 40 mins. Tested at 18°C.

Sheet thickness	Width of lap	Shear stress
mm.	mm.	kg./mm.²
0.5	3.0	3.4
1.0	3.0	4.7
2.0	3.0	5.5
3.0	3.0	5.8
0.5	6.0	2.1
1.0	6.0	3.6
3.0	6.0	4.4
0.5	13.0	0.9*
1.0	13.0	2.6
2.0	13.0	2.8
3.0	13.0	3.2
5.0	13.0	3.8
8.0	13.0	4.5
1.0	21.0	1.5†
1.0	30.0	1.1*

* Fracture in sheet in all cases.

† Third of test pieces showed fracture in sheet.

Table 2.—Shear Strength of Tube Joint in Avional, 2 mm. Wall Thickness; Radius of Contacting Surface=12.5 mm.; Width of Lap=40–42 mm.; Araldit Bond Cured at 200°C. for 40 mins.

Specimen	Area of bond	Breaking load	Shear stress
	mm.²	kg.	kg./mm.²
1	3,140	5,850	1.9
2	3,300	5,950	1.8

this adhesive may vary with the nature of the materials being joined, according to the kind of material (metal) and according to the nature of the resin; each bonding problem has to be considered as an independent entity. Factors which, singly or together, are of importance, are the respective polarities of the resin and the metal, and the chemical and lattice properties of the resin and metal (surface). It is important that the surface of the material, such as the oxide film on aluminium, be securely anchored to its base, otherwise fracture between surfacelayer and substrate material may occur.

Pure Araldit resins have the following mechanical properties:—Tensile strength, 10,000-11,500 lb./sq. in.; bend strength, 17,000-18,500 lb./sq. in.; impact bending strength, 18,500-20,000 lb./sq. in.; modulus of elasticity, 30,000-31,000 kg./sq. cm.

The mechanical strength of a resin-light-metal bond is best assessed in terms of shear stress. Two strips, say, of Avional, of 1-in. width, are roughened at the faces to be joined, the strips being then pre-heated to about 100 degrees C., brushed or sprinkled with resin, and then lightly clamped together. Curing, at 120-200 degrees C., is best carried out in a well-regulated oven.

The strength of resin-light metal bonds has been tested under exposure to cold and hot water, petrol, benzene, methanol and acetone. The bond remains unimpaired in water for normal periods of exposure, but water at 90 degrees C. causes a slight drop in sheer stress.

Plastic-bonded joints are intended not to replace, but to supplement the older systems. Even if shear stress with smaller overlap is equal to or even superior to that of riveted joints, the bond strength is obviously lower. In English usage the terms "peel resistance" and "stripping resistance" have been introduced to denote this distinction. The bonding strength values for the Araldit-light metal joint may approximate to that of a soft soldered joint.

Table 3.—Relationship between Shear Strength and Temperature. Araldit Bond between two 25 mm. Avional Strips with 13 mm. Lap. Cured at 200°C. for 40 mins.

Temperature °C. (Temp. held for 10 mins. before stressing)	Shear stress
	kg./mm.²
20	2.3
40	2.2
60	2.2
80	2.2
90	2.1
100	1.9
110	1.0
120	0.7

Table 4.—Cold Strength of Araldit Bond between two 25 mm. Avional Strips with 13 mm. Lap.

Temperature	Shear stress
°C.	kg./mm.²
+20	2.4
−58	2.3

Table 5.—Resistance to Water and Organic Solvents of Araldit Bond between two 25 mm. Avional Strips with 13 mm. Lap. Test carried out Half-hour after Removal of Specimen from Bath.

Medium or solvent	Period of exposure	Shear stress
	days	kg./mm.²
—	—	2.4
Water 20°	10	2.2
Water 20°	30	2.2
Benzine	10	2.4
Acetone	10	2.3
Methanol	10	2.2
Benzol	10	2.0
Water 90°	10	1.6
Water 90°	30	1.4

Investigations at the National Physical Laboratory

DURING the war years it was not possible to make known to the general public the nature and scope of the work of the National Physical Laboratory. This year the annual visiting days in June were revived with an exhibition of equipment and demonstrations of work in progress provided mainly for the enlightenment of delegates to the Empire Scientific Conference, university staffs, and representatives of industrial organizations.

A special laboratory is devoted to the work of testing reinforced low-density materials, among which we found laminated plastics much in evidence. Here great stress is laid upon the necessity of standard working conditions as regards the water content of the materials. The atmosphere in this laboratory is therefore controlled at a temperature of 70 degrees F. and 55 per cent. relative humidity, and all test pieces are conditioned for one week and upwards before testing is commenced. Apart from tests concerning tortional rigidity, direct shearing, compression, determination of Poisson's ratio, etc., we were particularly interested in the production of strain-time curves under varying degrees of softening for plastics heated in a temperature-controlled electric oven. Considerable attention is also being devoted to de-lamination tests, carried out by aid of an Avery compression-testing machine suitably adapted to transmit pressure upon the end of the laminæ by means of a small hardened steel ball (1/10-in. diameter) held in a cone-shaped collar. These tests are conducted up to pressures of approximately 12 tons per square inch, and it is hoped to correlate the results with the usual compression tests.

So-called "sandwich" materials exhibited included viscose sponges treated with phenol formaldehyde resin, calcium alginate cores with reinforced plastic skins, short tubes or resin-impregnated manilla or kraft paper in loose regular arrangement between two sheets of plywood, wood stringer constructions, and the like from British, American and Continental sources.

In the lubrication laboratory researches were in progress on kinetic boundary friction and the phenomenon of "scuffing." Here tests were also being made upon plastic bushes for water-lubricated bearings with a view to determining the temperature at which such bearings commence to sieze. The particular specimen upon the machine at the time of our visit was a fabric laminate of the phenol formaldehyde type intended for use on rolling mills.

The measurement of surface finish is also engaging the attention of the Laboratory. One of the many factors which affects the performance and life of engineering products is the degree of finish attained on mating surfaces. The type of finish required depends on the function and purpose of the component; for example, on aero-engine gudgeon pins a fine overall finish is essential in order to reduce the rate of wear and thereby increase the life of the part, yet on brake drum surfaces a rougher finish is desirable in order to promote friction.

Surface finish may be defined as the fine irregularities which occur on machined surfaces and arise from the cutting action of the machine tool used. The depth and shape of these irregularities form a well-defined pattern or texture which is characteristic of the machining process used and, to an experienced observer, can be identified by visual examination. The rough assessment of surface quality by visual examination or sense of touch is now giving way to precise methods of measurement.

The Microscopic Examination of Plastic Materials

VI.—Mouldings: (a) Fillers (Wood Flour)—contd.

By J. H. WREDDEN, F.R.M.S.
(Chief Chemist, Igranic Electric Co., Ltd.)

In the June issue the author dealt with the flours obtained from softwoods and hardwoods. The present contribution continues that subject, and leads on to a consideration of flours derived from other woody material, such as coconut shell and walnut shell.

FLAX SHIVE is the woody residue which remains after the fibre has been extracted from the familiar flax plant. We see in Fig. 99 a longitudinal section of flax shive at a magnification of 70 diameters, from which it will be noticed that the material is entirely composed of Xylem tissue; the lignification, however, is not particularly high, and therefore we may conclude that the strength is likewise not of a high order. As a matter of fact, the material tends to be somewhat brittle, but it should, when ground, produce a filler giving results comparable to those shown by a softwood flour.

A further view of the structure of this material is shown in Fig. 100, which is a photomicrograph of a transverse section of a piece of flax shive at a magnification of 110 diameters. The vessels and tracheids may be seen to be of very much the same size and to possess comparatively thin walls. As the plant is an annual, this Xylem, of course, represents the growth during a single year, as a result of which there is no development of a dense interlaced structure due to the presence of medullary rays, which in all probability accounts for the lack of strength in this tissue when compared with that of the denser woods. However, this particular case is mentioned in order to illustrate the inherent possibilities present in the annual plants.

In the foregoing discussions of the structure of wood fibres the importance of the presence of lignification has been stressed. The reason for this was the apparent increase in fibre strength due to an increase in lignification; that is to say, the higher the degree of lignification the higher the fibre strength to be expected. This was shown to be the case because the wood became more highly lignified and in consequence harder, so the fibre strength increased.

The importance of a high lignin content has been realized of recent times, as a result of which much work has been done with a view to increasing the lignin content of wood flour fillers by treatment with lignin compounds extracted from the waste sulphite liquors resulting from pulp-making processes. The lignin is used to enrich standard fillers, thus making it possible to produce workable moulding powder containing as little as 10 to 15 per cent. phenolic resin; one disadvantage, however, is that flow properties are impaired, but the electrical and mechanical properties are better. For example, it has been found possible to produce a moulding powder using a lignin-enriched filler to give an impact strength of 0.8 to 10 ft.-lb. per inch of notch; likewise, resistance and dielectric strength, etc., are improved, as are flexural and tensile strengths.

From this we see that a high lignin content in the filler is desirable from the point of view of economy and the production of a higher grade of moulding, but it is not quite clear at present as to exactly what part the lignin plays. It is the opinion of some that the lignin acts as an extender only, due to its own

thermoplastic properties in the presence of moisture and its compatibility with phenolic resins. It is also thought to take part in the reaction of phenolic resins, thus acting as a modifying agent as well as an extender. However, the exact function of lignin in this form is not clearly defined.

It is possible that the functions might depend on the form in which the lignin is available, as in the form of an enriching agent the pure lignin is added to the filler and does not appear to go into chemical combination with the filler constituents; thus, in the case of a lignin-enriched filler the lignin is available in the more or less pure state. In contradistinction to this, the lignin in the vessels and tracheids of a wood flour is in the combined state, thought to have been brought about by the combination, through its reactive groups, with basic cellulose and hemi cellulose originally developed by the plant.

So we see that, owing to the different forms in which the lignin is available, it is probable that different results will be obtained. It seems, however, to be generally true that the presence of lignin in either form would lead one to expect better results.

Further evidence of this is available in the behaviour of nut shell flours when used as fillers; for example, Schueler (see February issue) has shown that coconut shell flour, when used in certain proportions with a phenolic resin, is capable of producing improved characteristics in a moulding than wood flour. As we shall see subsequently, the shell is very highly lignified and the lignin appears to be in an almost free condition, as witnessed by the fact that it is possible to produce a moulding with the aid of moisture from the coconut shell flour alone, which indicates that the lignin behaves as if it were the pure substance and not in combination with cellulose, although it must be borne in mind that there is no definite proof that the lignin as found in tracheids and vessels does not behave as does the pure material. The degree to which lignin will behave in this manner may very probably be a function of lignin concentration.

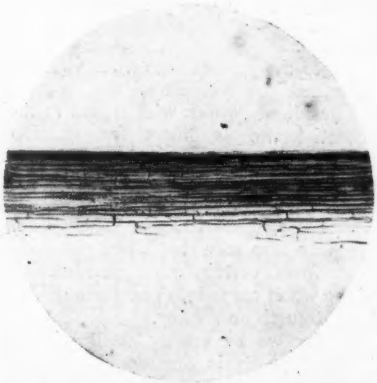


Fig. 99.—Longitudinal section of flax shive. Mag. 70 diameters.

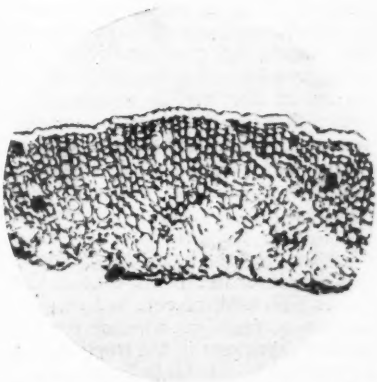


Fig. 100.—Transverse section of flax shive. Mag. 110 diameters.

Earlier in this article we formed a theoretical concept of an ideal shape for the filler particles. In order to develop maximum mechanical strength in the finished moulding, the evolution of this shape ignored such factors as bonding between resin and particle surface and complete impregnation of the filler with the resin; in fact, we presumed no cohesion between the resin and filler, but this factor is of importance because if

we go to the other extreme and presume the existence of perfect surface bonding, then clearly we may modify the ideal shape considerably. In these circumstances the filler may be a plain cylinder and, at the same time, we can see how the presence of available lignin will help matters as, owing to its behaviour in the presence of moisture obtained as the result of the condensation and its miscibility with the resin, will effectually produce a surface bond whose efficiency will depend on the lignin content in the resin. This will, of course, be a purely mechanical function; whether the lignin actually takes part in the reaction or not has still to be established on a definite basis.

Thus we see that by using a wood which is rich in lignin it is probable that additional strength will be obtained, and also the question of particle shape of the filler is given a much wider scope and does not assume so great an importance as would be the case if there was not bonding at the resin-filler interfaces.

The question of impregnation of the filler would appear to be of some importance, particularly in the case of mouldings used for electrical purposes. The filler particles should obviously be completely impregnated and, as these have been shown to consist of bundles of tubular elements, it is difficult to see how this is to be achieved without some kind of pre-treatment being applied to the wood flour whereby each particle is impregnated with resin, probably by solution methods, before being incorporated into the main mass. This would appear to be necessary, as the incorporation of the raw wood flour into the resin does not impregnate the filler particles, and it is very doubtful whether the heat and pressure used in the moulding process does this to a satisfactory degree.

The complete impregnation of filler particles is necessary if the optimum electrical characteristics are to be developed, for incomplete impregnation will lead to the formation of pockets of air and water vapour, of which a certain percentage of the latter has to be put up with, as we have seen.

Fig. 101.—Portion of flour particle (Teak). Mag. 365 diameters.

Whether complete impregnation will increase mechanical strength is problematical. It is probable that impact strength will decrease as incomplete impregnation of filler particles will leave them in a condition to absorb a certain amount of shock and thus help in withstanding impact stresses; on the other hand, complete impregnation would tend to lessen this characteristic and hence have an adverse effect on impact strength, but, generally speaking, it would appear to be highly desirable to have complete impregnation of the filler particles where good electrical characteristics are required.

Up to the present time we have mainly examined the coniferous and some of the deciduous woods with regard to their potential use as fillers for moulding powders. We have seen how the structure of the wood plays an important part in the development of mechanical and electrical characteristics in the moulding. We have also seen that when reduced to flour form, certain other characteristics of the wood come into operation, such as fibre strength and shape.

So far we have only dealt with the "dicot" plants in any detail, and it is now proposed to examine a product produced from a "monocot" plant, but before proceeding with this it would, per-

haps, be as well to take a look at some of the types of structure which might be met with in fillers made from deciduous woods. This information will be useful when it comes to the examination of finished mouldings, with a view to determining the filler used.

In Fig. 101 we have a photomicrograph of a particle of flour prepared from teak wood. This is taken at a magnification of 365 diameters, and shows a part of a bundle of tracheids and vessels together with a portion of a medullary ray. Filler particles of this type of structure may frequently be seen in mouldings irrespective of the nature of the wood used, hence this structure is a sure indication that there is wood in the filler. A closer examination has to be made, however, in order to determine whether the wood is deciduous or coniferous; this depends on whether the lignification of the vessels is visible or not. In this particular case, the pitting is not very clearly seen, although some small pits are visible at "A"; these are sufficient to show that the wood is not coniferous, for we know the characteristic coniferous pits to be much larger and of a different type.

The portion of medullary ray is not clearly visible except at "B"; the remainder of it is seen as dark patches, such as that shown at "C." This is due to the fact that it happens to be underneath the tracheids, and at this magnification the depth of focus is not sufficient to include it. The ray is visible through the tracheids, however, by virtue of the pigment present; this latter is another means of identification.

Another type of structure which may be encountered when examining portions of a finished moulding is that shown in Fig. 102, this being a portion of an ash particle photographed at 365 diameters. In this illustration two tracheids in longitudinal section are seen at "A" and "C"; there is also sufficient of the lignification visible to indicate quite definitely that the wood is of a deciduous character. There are also two or three tracheids in transverse section to be seen at "B," and here again we have an indication of the type of wood by the irregular cross-sectional shapes. Thus we see another of the different types of particle structure liable to be found in the moulding filled with wood flour.

We have seen previously how some particles of these hardwood flours tend to be produced in the form of relatively thin sections of bundles of tracheids. Beechwood appears to exhibit a stronger tendency to this form of particle than the other hardwoods examined, therefore it is proposed to examine such a particle of beechwood flour. This is shown in Fig. 103, at a magnification of 365 diameters. From this illustration it will be seen that the cross-sectional shapes of the tracheids are quite different from, and much more irregular than, those found in the softwoods. This point is being emphasized somewhat, as this type of filler particle is liable to occur in both hard and softwood flours, and may be used as a valuable guide to the identification of the type of wood used in a filler, particularly in cases where the presence of a mixture is suspected.

We will, however, deal with this aspect of the subject in greater detail subsequently. In general we may say that the two types of wood are fairly easily distinguished one from the other by virtue of the different types of microstructure

Fig. 102.—Portion of flour particle (Ash). Mag. 365 diameters.

exhibited by them. In the main each type possesses basic structural characteristics which serve as a reliable guide in their identification. These characteristics, which include types of lignification, tracheid length and cross sectional shape, are so different in the coniferous woods from those found in the deciduous woods, that they constitute unmistakable identification marks, as it were; for we have seen that the conifers possess only one type of lignification, the bordered pit (see June issue), which appears only on two opposite sides of a tracheid whose quadrilateral cross section is characteristic and typical. We also find that the presence of resin ducts and lignified tracheids in the medullary rays are again peculiar to the coniferous woods, as none of these structures are found in this form in the hardwoods. These latter, on the other hand, possess structures which may be regarded as being characteristic of these woods as a group; they include the multiple types of thickening and pitting of tracheids not found in the conifers; they also include the large, continuous vessels which again are absent in the conifers, which latter are composed of short tracheids. We have also seen that the deciduous woods are generally more highly lignified than the coniferous, and, furthermore, they do not possess resin ducts; in other words, the hardwoods are non-resinous. There is one aspect of the hardwoods which is worthy of mention, and, indeed, it might very well include the softwoods, and that is the effects of the chemical constituents of the woods, other than lignin and cellulose, which might affect the reaction of the resins with which they are mixed, one way or the other. One good example of this is the tannin content of oak. These constituents are, of course, present in the wood normally in contradistinction to those which may be produced by pyrolytic processes in the breaking down of the wood into flour, and also during the heating which takes place while the moulding is being made; as has been pointed out by Gerland,* appreciable quantities of acetic acid are produced by

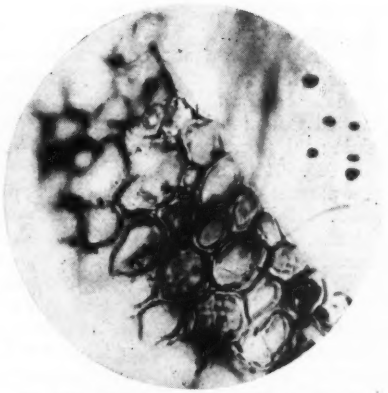


Fig. 103.—Portion of wood flour particle (Beech). Mag. 365 diameters.

these means, and it is the presence of this and other acid bodies which call for some slight attention in the consideration of wood flour as a filler.

The presence of acidic substances in wood is well known, for example, the resinous softwoods contain appreciable quantities of acid by virtue of the resin present, which is quite simply demonstrated by taking a pH value of an aqueous extract. Thus in Table I we see

Table I.

Type of Wood Flour	pH of Extract
English Beech	6.75
English Oak	4.75
Swedish Softwood	5.6

the result of measuring the pH of three types of wood flour extracted with hot distilled water.

From these figures we see that English oak possesses a considerable acidity; this is a characteristic of this wood which is well known. The acidity of the Swedish softwood, however, is unexpectedly high in comparison with that of beech, although it must be borne in mind that these figures are taken on the pro-

* Gerland, "Woodflour-filled Phenolic Resins in Tropical Climates," "Plastics," March, 1946.

cessed wood flour, and as samples of the original wood from which the flour was made were not obtainable, it is impossible to say how much of this acidity is due to process pyrolysis and how much of it occurs naturally. This has yet to be established and is of some importance, inasmuch as if the majority of the acidity is due to pyrolytic action, then it would appear to be necessary to modify the grinding processes in order to minimize any tendency to pyrolysis. It is also possible that some woods are more resistant to this heating than others.

However, we see from Table I that beechwood is the least acid of the three specimens chosen (which were taken as being representative of the more readily available woods) and so would appear to be the most suitable, particularly so in view of the fact that for electrical purposes the presence of acidic bodies in the finished moulding are far from desirable, owing to their disastrous effects upon the electrical properties of the product.

It is not proposed to discuss this point at any great length, but it is worthy of attention owing to its importance in connection with the production of high electrical strengths. Another aspect of this point is the possible inclusion of free phenol in mouldings, due to incomplete curing. This, together with the reaction water, is liable to have a similar effect on the electrical properties, although somewhat minimized by the use of resins, in which the last stage of curing should be anhydrous.

Thus we see that, generally speaking, we should not expect wood flours to produce the best electrical mouldings, due to the presence of chemical constituents of an acidic nature. Likewise, they should not be expected to produce mouldings of great mechanical strength due to the nature of their microscopic structure, although it does appear to be possible to improve matters in this direction by investigation of methods of reducing the wood to flour form, with the object of obtaining the highest percentage of the most efficient particle shape; also it would seem probable that much can be done by a suitable choice of species of wood.

There is, however, one important aspect of the problem not so far discussed. This is the question of the method of incorporating the filler into the resin. We have seen previously that for maximum electrical strength we require an homogeneous product in which the filler is completely surrounded and embedded in the resin matrix, so that there are no air pockets or voids of any kind present, where gaseous or liquid products might condense. This obviously points to the necessity for completely impregnating every filler particle with the resin. The usual method of incorporating the filler is to mill it into a plastic mass of the resin, together with suitable pigments, etc., on heated rolls. This method cannot be expected to impregnate the filler, but rather to produce an intimate mixture of resin and filler. It must be remembered, however, that a certain degree of impregnation is achieved in the moulding press due to the liquifaction of the resin and the pressure applied, but this does not by any means completely impregnate the filler, as we shall see subsequently. The dependence of moulding conditions on the degree of moisture absorption is demonstrated by the increased moisture absorption and swelling exhibited by moulded materials produced under decreasing moulding pressures. Apart from this the type of filler and resin content influences this characteristic, thus Gerland (*loc. cit.*) gives it as his opinion that a well-saturated fibrous filler composed of coarse fibres and powders containing 40 per cent. resin show greater absorption of moisture than those containing 50 per cent. resin, this apparently being due to the better impregnation of this filler with higher resin contents, for the same moulding condition, likewise the pigments employed have an influence on the final product.

It would appear, therefore, that if we want to impregnate the filler completely, and without any doubt, we must look to the method of mixing. We have seen that the moisture content of wood has a

great influence upon its strength and we know that if we desire to obtain the greatest efficiency from wood flour as a filler, we must leave a moisture content of some 4 or 5 per cent. This, of course, sets a limit to the capabilities of wood flour, so far as electrical characteristics are concerned, nevertheless improvements on present-day practice would appear possible in other directions, such as the method of mixing. One method of obtaining better impregnation of the filler, which suggests itself, is to pre-treat the filler with resin. This could consist of treating the filler with a thin solution of resin in a volatile solvent such as acetone, which may even be carried out under reduced pressure, to remove all air from the interstices of the filler particles. This would then be replaced with resin solution by the application of pressure to the mixture, after which the solvent may be evaporated off and recovered for further use by the usual means. This treatment, if carefully carried out, would leave each particle of filler thoroughly impregnated and coated with a small amount of resin.

If the impregnated filler is milled with resin in the usual way to make a moulding powder, it will be appreciated that we now have much greater prospects of producing a moulding with an homogeneous structure, conforming to the ideal. This might, at first sight, seem to suggest a reversion to the old method of preparing moulding powders by the wet process, but it is, in fact, a combination of the wet and dry processes in which the older method is used more efficiently.

Thus we see one way in which matters may be improved somewhat, and no doubt there are other means whereby the same end may be achieved; but whatever the method, it would seem desirable that the incorporation of the filler into a moulding powder be such as to produce a more homogeneous product than obtained by present-day milling technique, particularly so when the mouldings are to be used for electrical purposes, and as the greater proportion of mouldings produced from phenolic powders are used for this purpose, it would appear that a certain amount of work on the subject and even a slightly increased cost would be justified, so far as the wood-filled materials are concerned.

(To be continued.)

The Simplicity of Chain Molecules

(Continued from page 340)

way the silkworm spins silk, or the spider spins its web. In the synthetic fibre industry, of which nylon is the most famous product so far, and also in the plastics and synthetic rubber industries, we go one better; we actually build up the molecules ourselves—new molecules that is.

Now I do not suppose anyone will have picked up anything precise out of what I have just been saying—there has not been time for that—but at least I hope I have made the point of the indivisibility of science, and how that, too, is just one long chain-molecule, a chain of natural knowledge that runs through schools, universities, factories, hospitals, and so on, out into an unknown of never-failing wonder and thrills. . . .

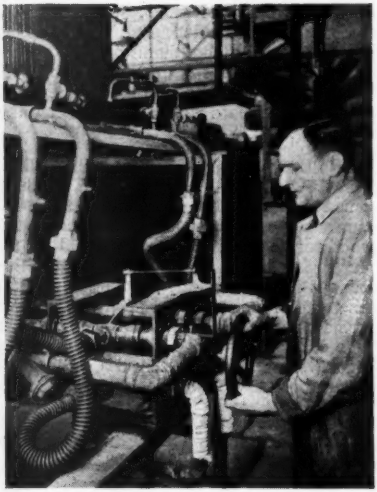
PROF. ANDRADE: I am so glad, Astbury, that you have brought up this matter of the excitement of the scientific chase after the unknown, and the beauty of the strange singularities that the scientist discovers.

Disposal of Synthetic Rubber Plant

The War Assets Administration in the United States has recommended to Congress that ten Government-owned synthetic rubber plants costing $182,000,000 be placed on the market. If accepted, these surplus rubber plants will be the first to be offered to private industry. The ten rubber plants represent the entire butyl rubber capacity of the United States, as well as more than 90 per cent. of the styrene capacity, 86 per cent. of neoprene, 10 per cent. of furfural and 8 per cent. of the carbon black capacity.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes



QUICK-ACTION CHANGE-OVER FOR HYDRAULIC SYSTEMS.—We illustrate a compact unit embodying novel features, which has been developed to provide a quick-action change-over for pipe lines on hydraulic systems. It is rather analogous to an electrical power-house switch in the sense of being positive, foolproof and rapid. The makers are Exactor Control Co., Ltd., of London.

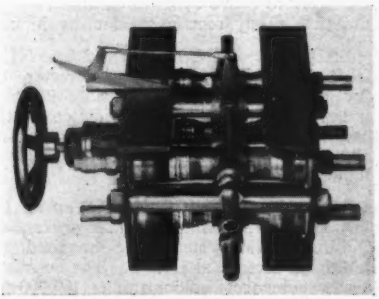
The installation shown was supplied to Standard Telephones and Cables, Ltd., Enfield. The engineers of this concern had for some time felt dissatisfied with manual methods of changing-over the circulation through the bowls of their rubber-mills from high-pressure hot to cold water supply and back again. The operation is normally carried out several times in a day, and after certain unfortunate experiences of interconnected services due to wrong valve operation, it was considered necessary to ensure physical disconnection of one service pipe before another was connected.

The initial experiments utilized Exactor self-sealing pipe couplings mounted as individual units, i.e., one-half coupling per service, the machine feeds (flow and return) being connected manually to the appropriate service connections. This method ensured physical disconnection of the services but was attended by a number of difficulties and delays when handling hot service pipes, with consequent loss of production time.

From the experience so obtained, Exactor Control Co. developed their new change-over unit, with which it was found possible to perform a complete switch from one service to another in 15 seconds, and in one entirely foolproof action. In addition, it is an equally simple matter to throttle the flow through the system to any desired degree and thus have an infinitely variable temperature control at the local point where it is needed.

The essential feature of this switch-unit is an automatic self-sealing coupling, which may be described as a form of pipe union comprising two mating halves, each incorporating a sliding internal valve. As will be seen from one of the illustrations, a frame carries eight female half-couplings rigidly mounted in a group of four at each end. Of the four at one end, two are connected to the high temperature supply and two to the high temperature return system; the four at the other end connect with the equivalent low temperature supply and return.

On a central threaded spindle, supported in guides, rides a sliding carriage bearing eight male couplings; four face each way and all are axially aligned with corresponding fixed female halves. Each male half-coupling communicates directly via a passage in the



Exactor "switch" unit for hydraulic systems showing half-couplings.

carrier casting with its opposing male half-coupling on the same axis. In this arrangement there are four such connecting passages running through the carriage; each has a midway port provided with a normal pipe thread, and to these ports the inlet and outlet services are coupled. Flexible hose is used to allow for lateral movement of the carriage.

For rotating a control wheel attached to the central threaded spindle, the sliding carriage bearing the male half-couplings may be made to engage the inlets and outlets of either the high or low temperature supply and return at will; alternatively, the carriage may be moved to the mid-position, where no flow can take place and all pipe lines will be isolated. An indicator arm attached to the carriage automatically denotes its position to the operator.

Since there is no fluid passage connecting a disengaged supply service to the machine, it is quite impossible for any unintended flow to take place such as might occur through cocks or valves having defective seatings caused by wear or corrosion. The importance of this point in processes involving close temperature-control cannot be overrated.

The frame can be made to accommodate any number of pairs of couplings for various pipe sizes, according to the number of services to be simultaneously switched over. For example, where individual control of the circulation through single elements is required, a separate two-pipe two-way pipeline switch unit would be installed for each element.

Faced with a row of cocks or valves, some of which must be shut down before others are opened, an operator has opportunity for errors which may produce dangerous or costly results. Mechanical interlocks designed to prevent such mistakes, moreover, are likely to prove complicated and clumsy, and they rarely remain satisfactory in use.

BRITISH INDUSTRIAL PLASTICS, LTD.—Mr. C. H. Glassey, director of development, British Industrial Plastics, Ltd., has been appointed sales director. He has also been appointed sales director of The Beetle Products Co., Ltd., and of Beetle Bond, Ltd.

RENOLD AND COVENTRY CHAIN CO., LTD., precision chain engineers, of Didsbury, Manchester, have acquired an additional factory at Cardiff. The new factory, which covers a floor area of 130,000 sq. ft., will provide much-needed facilities to meet the increasing pressure of their power transmission business.

DE LA RUE INSULATION LTD.—Mr. John Barnard retired from this company on May 31 after thirty-one years' service. He joined Thomas De la Rue in May, 1914, and entered the plastics side of the business shortly afterwards. In 1941 he became general manager of the Laminated Plastics Section, which, in 1943, transferred to De La Rue Insulation, Ltd. A farewell party was held at Walthamstow factory and at Imperial House, Regent Street. Mr. Cyril Ashton, vice-chairman of the company, presented Mr. Barnard with a gold hunter watch from his many friends.

PROLITE TUNGSTEN CARBIDE-TIPPED CUTTERS.—Protolite, Ltd., have issued a leaflet briefly describing a further range of tipped cutting tools, primarily for woodworking. It is pointed out that the glues present in plywood and built-up sections has very abrasive qualities, and the inherent properties of cemented tungsten carbide are especially suited to resist the rubbing action which tends to dull cutting edges. We have also received a copy of the 1946 Prolite Die Maintenance Manual.

GLYN AND CO., LTD., formerly of Haywards Heath, announce that their new address is: Hampden House, 84, Kingsway, London, W.C.2.

THE DUNLOP RUBBER CO., LTD., is to increase the production of suits and clothing from plastics and the use of flexible synthetic resins as alternatives for natural and synthetic rubber in the manufacture of waterproof garments. Two new companies, Dunlop Clothing and Weatherproofs and Dunlop Special Products, are being formed.

MICANITE AND INSULATORS CO., LTD.—Mr. J. M. Fleming, M.A., B.Sc.Tech., M.I.E.E., has joined the staff of this company as chief development engineer. He received his electrical engineering training at the College of Technology, Manchester, afterwards proceeding to Gonville and Caius College, Cambridge, where he read physics in the Natural Science Tripos. Leaving Cambridge, Mr. Fleming served the College Apprenticeship course at Metropolitan-Vickers Electrical Co., Ltd., at the conclusion of which he was appointed to the Research Department, working particularly on insulation problems. He was awarded an International General Electric Company Fellowship, which he devoted to the study of insulation practice in America. In 1938 he joined B. S. and W. Whitely, Ltd., in charge of development work on

elephantide pressboards, and from 1943 to 1946 was loaned to the Ministry of Supply as technical advisor to the Mica Control. In 1944 he visited America as secretary of the United Kingdom Radio Materials Mission.

FRANCIS SHAW AND CO., LTD.—Mr. J. W. Howie, the London representative of this company, died May 25. He joined the company in 1914 as chief designer and estimator. He served on a number of technical committees for the rubber and plastics industries.

PITTER GAUGE AND PRECISION TOOL CO., LTD.—Mr. John C. Brown has been appointed secretary and accountant to this company. He has already taken over his duties.

PRINTING PLASTIC FILMS.—A new method of printing plastic films is claimed by the Plastics Guild Corporation of America. Five-colour printing, similar to that on paper, will be available. The film to be treated is softened slightly, and, while in this "semi-solvent" state, it is printed with inks containing ingredients compatible with the film itself, but also having a slight solvent action which causes the design to "bite" into the base. Initial production is to be 100,000 yards per day.

NEW SYNTHETIC OIL FOR PAINT.—At an exhibition of the Society of the Plastics Industry in New York, the Chemical Products Division of Goodyear Tyre and Rubber Co., Ltd., exhibited a new synthetic co-polymer resin called Pliolite S-5, which can be used as a substitute for natural oils and resins in the manufacture of indoor paints. It is an improvement on the original Pliolite, a natural rubber product, which was used widely by the paint industry prior to the war. It is said to be highly resistant to moisture, acids, alkalis and other corrosive chemicals.

THERMOSETTING RESINS FROM THIOPHENE.—The Socony Vacuum Oil Co., New York, have announced a new and cheaper method for producing thiophene from petroleum. The cost of the product is said to be commercially practical, whereas previously about 54 dollars per lb. Simultaneously, it has been indicated that thiophene, under suitable conditions, condenses with aldehydes to form thermosetting resins. The behaviour of thiophene in this respect would be rather like that of phenol, although having important differences.

THE KING'S BIRTHDAY HONOURS.—Mr. Clifford Copland Paterson, director of research laboratories, General Electric Co., Ltd., Wembley, received a knighthood in the King's Birthday Honours, published June 13. Mr. H. Grinstead, director of technical research and development, Ministry of Aircraft Production, and Mr. T. Walmsley, chief radio engineer, Air Ministry, received the C.B.E.

B.E.T.R.O. COUNCIL.—Mr. Ivor Cooper (Lever Bros., and Unilever, Ltd.), has completed his year of office as chairman of the Council of the British Export Trade Research Organization. The deputy chairman, Mr. Leslie Gamage, M.C., F.C.I.S., joint managing director of the General Electric Co., Ltd., has been elected chairman for the ensuing year. Mr. Leslie Gamage is succeeded as deputy chairman by Mr. C. Percy Lister, of R. A. Lister and Co., Ltd., engineers. At a time when electrical goods and machinery constitute the greatest single export item in money value in the monthly figures issued by the Board of Trade, the future of the B.E.T.R.O. will be watched over by two outstanding figures in these industries.

INDUSTRIAL DESIGN.—The Council of Industrial Design has appointed Mr. N. E. Kearley, A.M.I.E.E., as deputy director. Mr. Kearley has had a wide practical experience of the engineering industry in various technical capacities. In 1929 he joined the examining staff of the Patent Office, and later served for several years in the Industries' and Manufacturers' Branch of the Board of Trade. He has recently rejoined the staff of the Board of Trade as liaison officer in Germany.

PALESTINE TRADE.—The Economic Bureau for Palestine, representing official organizations of Palestine industry, trade, and finance, has been established in London. The Bureau will provide economic information on Palestine and will also function as a Liaison Office. Mr. Martin Lederman has been appointed director, his address being 12, Buckingham Palace Mansions, Buckingham Palace Road, London, S.W.1.

MR. H. COURTNEY BRYSON has been asked to prolong his contract with Fabrica Lusitana de Tintas e Vernizes Lda, the largest firm of paint and varnish manufacturers in Portugal, owing to progress with his work in reorganizing the factory. He will not be back in England until early in August, but will return to Portugal within a few weeks.

PATENT REVIEW

The following abstracts have been made from specifications at the Patent Office, with the permission of the Controller of H.M. Stationery Office. Complete specifications can be obtained from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

B.P. 576,253. Application date: 28.4.44. Convention date (U.S.A.): 29.4.43. Accepted: 26.3.46.

Improvements in or relating to Screw Pumps for the Extrusion of Synthetic Polymers. To: Imperial Chemical Industries, Ltd.

B.P. 576,263. Application date: 5.5.44. Accepted: 26.3.46.

Improvements in the Manufacture and Production of Coloured Threads, Filaments, Strips or Films of Cellulose. H. J. Hegan and S. Robertson. To: Courtaulds, Ltd.

B.P. 576,271. Application date: 26.3.43. Accepted: 27.3.46.

Improvements in or relating to the Manufacture of Synthetic Rubber. M. M. Heywood. To: Firestone Tyre and Rubber Co., Ltd.

Refers to vulcanizable butadiene rubbers. Organic accelerators and cyclohexylammonium cresylate or mono-cyclohexylammonium resorcinate are added to the rubber mix containing sulphur.

B.P. 576,279. Application date: 4.2.44. Accepted: 27.3.46.

Improvements in and relating to the Manufacture of Printing Plates and of Materials suitable for use therein. E. G. Couzens and P. S. Adamson.

Printing plates consisting of a sheet of hard polymerized thermoplastic material with an adherent backing of the same or another thermoplastic material which is soft and resilient. Examples: Polyvinyl chloride, polyvinyl acetate unplasticized, backed by the same material which is, however, plasticized; or unplasticized ethyl cellulose backed by plasticized ethyl cellulose.

B.P. 576,293. Application date: 13.3.44. Convention date (U.S.A.): 14.9.43. Accepted: 27.3.46.

Vinyl Halide Polymer and Copolymer Stabilization. To: Wingfoot Corporation.

Stabilization by addition of aminoguanidine salts (e.g., sulphate, nitrate, acetate, etc.) in quantities of 0.2-10 per cent. Mentions particularly films formed from copolymers of a vinyl halide and a dialkyl fumarate.

B.P. 576,362. Application date: 2.6.43. Convention date (U.S.A.): 3.6.42. Accepted: 1.4.46.

Improvements in or relating to the Manufacture of Coatings and Shaped Articles from Synthetic Linear Polyamides. To: E. I. Du Pont de Nemours and Co.

B.P. 576,363. Application date: 2.6.43. Convention date (U.S.A.): 3.6.42. Accepted: 1.4.46.

Improvements in or relating to the Production of Derivatives of Synthetic Linear Polyamides. To: E. I. Du Pont de Nemours and Co.

Refers to the manufacture of N-methylol polyamides.

B.P. 576,366. Application date: 22.3.44. Accepted: 1.4.46.

Improved Arrangements of a Thermocouple for use in connection with High Frequency Electric Heating Apparatus. J. C. Quayle and P. Jones. To: British Insulated Cables, Ltd.

B.P. 576,384. Application date: 8.1.42. Accepted: 2.4.46.

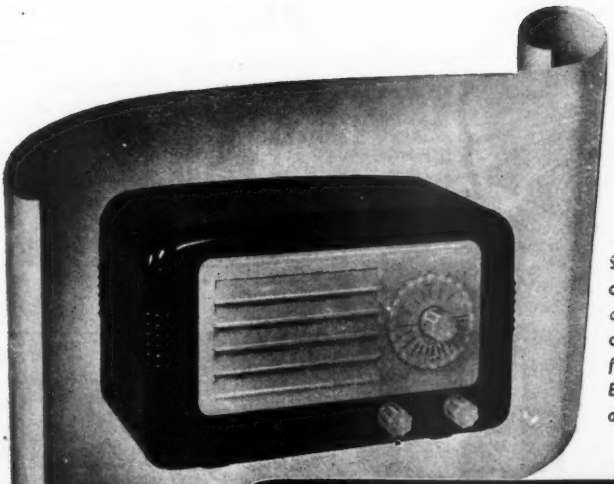
An improved Resinous Material and Products therefrom. J. F. Cowen. To: British Insulated Cables, Ltd.

Enamelled wire having a coating produced by dissolving a melamine aldehyde condensation product and a super polyamide in cresol and reacting this mixture to form a heat-hardenable melamine cresol-aldehyde resin.

B.P. 576,394. Application date: 6.5.44. Convention date (U.S.A.): 13.5.43. Accepted: 2.4.46.

Improvements in or relating to the Formation of Layers of Organic Polysulphide Polymer Plastics. To: International Latex Processes, Ltd.

Method of forming smooth coatings by direct deposition of polysulphide particles from an aqueous suspension by adding to such suspension 0.03-1 per cent. (by weight) of hydrogen sulphide in the form of an ammoniacal solution containing at least 0.75 vols. of hydrogen sulphide per vol. of ammonia. This plastic layer may be spread on to a backing surface.



Small radio cabinet in two contrasting colours, moulded for Champion Electric Corporation.

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B.P. 576,397. Application date: 4.9.44. Accepted: 4.4.46.

Improvements in or relating to the Manufacture of Vinyl Esters. H. F. Oxley, E. B. Thomas and W. G. B. Mills. To: British Celanese, Ltd.

Process for the manufacture of vinyl esters or substituted vinyl esters of fatty acids (including substituted fatty acids) by heating their ethylidene diesters in admixture with more than the equivalent quantity of the anhydride of the acid and an aromatic sulphonic acid as catalyst (i.e., benzene sulphonic acid, toluene, ethyl benzene, xylene or naphthalene sulphonic acid). The vinyl ester is removed from the reaction zone by distillation.

B.P. 576,411. Application date: 8.11.44. Accepted: 2.2.46.

Improvements in Electric Cables. J. L. Miller, J. Conning and H. R. F. Carsden. To: British Insulated Cables, Ltd.

Refers to electric cables for very high working voltages, the conductor of which is surrounded by layers of dielectric material with gas under super-atmospheric pressure in the interstices. The dielectric material is enclosed in a sheath consisting of lead or a lead alloy suitably reinforced to withstand internal pressure. The invention consists in an improved form of dielectric, for instance polythene or polyvinyl chloride, containing a dispersion of high purity rutile (synthetic rutile). Other materials suitable for this purpose also mentioned are barium titanate, strontium titanate, beryllium titanate, calcium titanate.

B.P. 576,416. Application date: 6.11.42. Accepted: 3.4.46.

Improvements in and relating to the Manufacture of Styrene and the like. H. Steiner and S. Whincup.

Process for the manufacture of styrene or alkyl-substituted styrenes from ethyl-benzene or alkyl-substituted ethyl-benzenes by dehydrogenation, using ceric oxide with or without an addition of stable uranium oxides as catalysts. These catalysts are deposited on the oxides of beryllium, barium, magnesium, calcium or strontium. This process refers particularly to the transformation of isopropyl-benzene or n-propyl-benzene into α and β methyl styrene or o-, m-, p-ethyl toluene into o-, m-, p-vinyl toluene.

B.P. 576,418. Convention date (U.S.A.): 23.5.42. Accepted: 3.4.46.

Improvements in or relating to Resin Bonded Composite Ply Products. A. A. Glidden and W. R. Hickler. To: B. F. Goodrich Co.

Relates to resin bonded composite ply products useful in aircraft structures produced from plys of thin wood veneers interposed with plys of fibrous material, the latter consisting of unwoven fibres in tenuous web form which are saturated or impregnated with resin.

B.P. 576,551. Application date: 9.10.44. Accepted: 9.4.46.

Improvements in or relating to Flexible Tubing and the Method of Manufacturing same. C. G. Lemon. To: Tenaplas, Ltd.

High-pressure tubing manufactured by applying to the outside of a flexible tube of thermoplastic material (polyvinyl chloride, neoprene, etc.) a reinforcing sleeve of woven or braided material and embedding the sleeve in the plastic by softening the latter by the application of heat and enlarging it.

B.P. 576,594. Application date: 15.12.43. Convention date (U.S.A.): 11.6.43. Accepted: 11.4.46.

Improvements in Thermosetting Plastics. To: Wingfoot Corp.

Relates to improved thermosetting plastic compositions of increased tensile strength and in particular to the effect of guanidines on such compositions. Vinyl chloride and vinylidene chloride copolymers heated in the presence of guanidines yield compositions of improved modulus of elasticity and greatly lessened solubility in various solvents. This invention also refers to the treatment of the copolymer in the presence of heat-hardenable phenol formaldehyde thermosetting resins.

B.P. 576,646. Application date: 28.3.44. Convention date (U.S.A.): 30.3.43. Accepted: 12.4.46.

Improvements in or relating to the Twisting of Artificial Fibre Yarns. To: International Oil Co.

Treatment of artificial fibre yarns by applying, prior to twisting, an aqueous emulsion containing a hydrogenated vegetable, animal or marine fatty oil of a melting point above 30 degrees C. and subsequent drying and twisting with or without the application of heat.

B.P. 576,647. Application date: 29.3.44. Convention date (U.S.A.): 31.3.43. Accepted: 12.4.46.

Improvements in or relating to Filamen-

tous Structures of Synthetic Linear Fibre-forming Polymers. To: Imperial Chemical Industries, Ltd.

B.P. 576,665. Application date: 14.12.43. Convention date (U.S.A.): 10.6.43. Accepted: 15.4.46.

Improvements in Synthetic Rubber Dispersions. To: Wingfoot Corp.

Process for the manufacture of aqueous adhesive dispersions by masticating a solid hydrophilic adhesive protein with a solid rubber-like copolymer of butadiene-styrene and subsequent addition of water to the mixture whilst continuing the mastication process until an inversion of phase takes place. Proteins mentioned are casein, glue, albumen, dried blood, etc.

B.P. 576,697. Application date: 8.10.43. Accepted: 15.4.46. Divided out of B.P. 576,028.

Process for providing Plastic Articles with Metallic Coverings. L. Rado.

Process for giving plastic articles a metallic appearance in the course of the moulding process by producing a film from a transparent lacquer containing a metal powder and applying this film to the plastic surface whilst the plastic is still in the mould and soft and tacky. Pressure is subsequently applied.

B.P. 576,716. Application date: 6.6.40. Accepted: 17.4.46.

Production of New Organic Silicon Compounds. P. J. Garner.

B.P. 576,721. Application date: 19.2.43. Accepted: 17.4.46.

Improvements in and relating to the Preparation, Treatment and Application of Rubber-like Resins. L. A. Jordan and J. K. Aiken.

Refers to polysulphide rubber-like resins which may be used for moulding or compounding and can be vulcanized to yield products similar to vulcanized rubber, but possessing an enhanced degree of resistance to solvents and oils.

B.P. 576,744. Application date: 9.2.44. Accepted: 17.4.46.

Preparation of Chlorinated Rubber and other Chlorinated Rubber-like Materials and Chlorinated Rubber Hydrochloride. Communicated by: Hercules Powder Co.

Improvement consists in drying precipitated chlorinated rubber in contact with nickel surfaces maintained at a temperature between 50 degrees C. and 130 degrees C. The drying is effected under sub-atmospheric pressures until practically all the moisture is eliminated.

B.P. 576,745. Application date: 29.2.44. Convention date (U.S.A.): 4.3.43. Accepted: 17.4.46.

Improvements in or relating to Resinous Compositions. Bakelite, Ltd.

Process comprising the heating of a monohydric phenol with aqueous formaldehyde in the presence of an acid catalyst, treating the resin so obtained for the removal or neutralization of the acid and adding resorcinol and formaldehyde, paraformaldehyde, etc., and heating the mixture to the brittle stage. The heat reactive resin may also contain a hardening agent such as hexamethylene tetramine. Such resins may be used for moulding compositions, varnishes and adhesive or, when incorporated with rubber or polyvinyl butyral, may increase water resistance and hardness; also as a constituent of adhesive compositions for coating materials to the walls of tanks.

B.P. 576,785. Application date: 16.3.44. Accepted: 18.4.46.

Improvements in or relating to the Manufacture of Cellulose. H. Dreyfus.

Relates to the production of cellulose from materials containing ligno cellulose and especially from straw. The process comprises treatment of the ligno cellulosic material with a hot aqueous aliphatic alcohol (ethyl alcohol) containing a small proportion of mineral acid (hydrochloric acid) under such conditions that the greater part of the lignine is rendered soluble in dilute solutions of alkalis, and treatment of the product so obtained with a hot dilute solution of an alkali metal hydroxide.

B.P. 576,800. Application date: 3.5.44. Convention date (U.S.A.): 3.5.43. Accepted: 18.4.46.

Improvements in the Production of the Formal and Hemiformal of Ethylene Cyanohydrin. To: E. I. Du Pont de Nemours and Co.

B.P. 576,830. Application date: 16.10.42. Convention date (U.S.A.): 1.11.41. Accepted: 23.4.46.

Improvement in or relating to the Interpolymerization of Ethylene and Vinylidene Chloride. E. I. Du Pont de Nemours and Co.

Refers to the polymerization of vinylidene chloride and ethylene in the presence of a polymerization catalyst (benzoyl peroxide or persulphate) at temperatures be-

tween 50 and 150 degrees C. and 200-1,000 atmospheres. The pH of the solution may be adjusted and other vinyl compounds may be added.

B.P. 576,913. Application date: 3.3.44. Accepted: 26.4.46.

Derivatives of Hydrolized Interpolymers of Ethylene and Vinyl Organic Esters. W. H. Scharky. To: E. I. Du Pont de Nemours and Co.

Refers to the manufacture of sulphates and sulphonates of hydrolized interpolymers of ethylene and a vinyl organic ester comprising esterification of the hydrolized interpolymers with a sulphur-acid halide.

B.P. 576,938. Application date: 6.6.40. Accepted: 29.4.46.

Production of New Organic Silicon Compounds. P. J. Garner.

B.P. 576,944. Application date: 22.6.43. Convention date (U.S.A.): 23.6.42. Accepted: 29.4.46.

Improvements in and relating to Resinous Polymerization Products. British Thomson-Houston Co., Ltd.

Preparation of copolymers by reacting under heat and in the presence of a polymerization catalyst a mixture of soluble, fusible, heat convertible, partial polymers of para- or meta-divinyl benzene and an unsaturated alkyd resin. These interpolymers may be used for casting, moulding, adhesives, impregnants, etc., and may also be employed for the coating of paper, glass, concrete, etc.

B.P. 576,995. Application date: 23.5.44. Convention date (U.S.A.): 5.10.43. Accepted: 30.4.46.

Hardenable Compositions containing Urea Aldehyde Resins. R. R. Harris. To: American Cyanamid Co.

Relates to stable compositions containing a urea aldehyde resin and a curing catalyst (ammonium silico-fluoride or ammonium boro-fluoride).

B.P. 577,021. Application date: 21.7.43. Convention date (U.S.A.): 23.7.42. Accepted: 1.5.46.

Improvements in or relating to Aromatic Amine-Aldehyde Resinous Products. To: Norton Grinding Wheel Co., Ltd.

Refers to the production of shaped articles using polymerized condensation products of a primary aromatic amine (aniline) with formaldehydes. Glycerol tri-monochloracetate or trimethylol propane tri-monochloracetate is used as plasticizer.

B.P. 577,073. Application date: 30.12.42. Convention date (U.S.A.): 31.2.41. Accepted: 3.5.46.

Improvements in or relating to Plastic, Elastic Rubber-like Substances. To: Standard Oil Development Co.

Refers to the manufacture of copolymers with a low iodine number, which are capable of reacting with sulphur. A mixture of dodecyl methacrylate and citronellyl methacrylate is treated with benzoyl peroxide as catalyst at a temperature of approximately 90 degrees C.

B.P. 577,103. Application date: 12.1.43. Convention dates (Switzerland): 14.1.42 and 21.10.42. Accepted: 6.5.46.

Process for the continuous Esterification of Regenerated Cellulose and the like. To: Society of Chemical Industry in Basle.

Continuous esterification of shaped materials made of regenerated cellulose. A suitable catalyst (potassium acetate) is applied and the material then treated with a liquid esterifying agent (organic acid anhydride). The material still charged with esterifier and the catalyst is then subjected to a short heat treatment with heated gas.

B.P. 577,137. Application date: 21.6.43. Convention date (U.S.A.): 23.6.42. Accepted: 7.5.46.

Improvements in and relating to Resinous Polymerization Products. To: The British Thomson-Houston Co., Ltd.

Preparation of an insoluble, infusible copolymer by forming a solution of a soluble, fusible, heat convertible partial polymer of para- or meta-divinyl benzene and a compound containing $CH_2 = C <$ groups and subsequent polymerization by heat.

B.P. 577,256. Application date: 5.5.44. Accepted: 10.5.46.

Improvements relating to Moisture-proofing coating compositions. M. F. Monbiot.

Coating composition for waterproofing paper, etc., consisting of ethyl cellulose, plasticizer and paraffin wax.

B.P. 577,288. Application date: 22.6.43. Convention date (U.S.A.): 23.6.42. Accepted: 13.5.46.

Improvements in and relating to Resinous Polymerization Products. To: The British Thomson-Houston Co., Ltd.

Preparation of heat-convertible, soluble, fusible partial copolymers of para- or meta-divinyl benzene and a compound containing a plurality of non-conjugated $CH_2 = C <$ groups.

The Silicon Plastics (continued)

By E. E. HALLS

In this instalment the author discusses silicone-resin insulations with particular reference to magnet coils. He also treats of synthetic rubbers of the silicone type.

DURING the progress of development of the silicone resins by chemists and engineers of the Dow Corning Corporation, the engineers of the Westinghouse Electric and Manufacturing Co. checked their possibilities in electrical machines and apparatus, with the result that life tests have been completed in the minimum of time, and the best available silicones have been fitted into specific applications. G. L. Moses gives a survey of the results under the heading of "New Silicone Resins Boost Insulation Temperature Limits" in the "Westinghouse Engineer," September, 1944, p. 138. In addition to some of the information given in the previous extracts, the following data is included in this source.

Moses tabulates the insulation materials that comprise a combination of silicone resins and various inorganic materials. These high-temperature silicone insulation materials are designated H.T.S. until AIEE or NEMA insulation classes corresponding to them are standardized. They are shown in Table 15, which classifies the materials, summarizes the forms in which they are available, and the use to which they can be applied successfully.

An example is cited, namely the build-up of the insulation for a typical traction motor. In this, with the silicone-insulation technique, the coils are insulated with silicone-bonded glass-mica tape, a glass and mica wrapper, covered with silicone-sized glass tape and finally insulated with silicone varnish. Again, for a small induction motor, other members of the silicone family are included. The stator is wound with silicone-treated glass-covered magnet wire; the coils are insulated from the core and between phases by mica and glass slot cells, silicone bonded. The stator is then impregnated and finally dipped in high-temperature silicone varnish to provide the waterproof external coating.

Moses states that data collected on coils in service confirm the laboratory tests that show the excellent waterproofing characteristics of silicone insulation. It is claimed that water has little effect. In the dried but unaged condition, the silicone films possess a water permeability value equal to the better organic insulating varnishes or to soft vulcanized rubber. After ageing for one month at 200 degrees C., whereas the organic films show erratic and high-moisture permeability, the silicone films actually improve slightly with ageing at this temperature.

The tremendous advantage of H.T.S. insulants over the conventional class B insulation for thermal endurance has been demonstrated by the subjection of coils to thermal ageing tests. It is important to note that severe vibration has been combined with thermal cycling in order to check the endurance value of motors. For example, a D.C. motor armature was severely vibrated during thermal cycling, the latter being obtained by applying 75 amps. 72 times/min. from a 420 V.A.C. supply. This load was held for three minutes, and tests continued for 16 hours a day for 36 days. Temperatures of 230 degrees C. were observed. The coils tested included the following types of insulation:—Mica tape, glass and asbestos wire covering with various types of mica wrapper, and glass and asbestos finishing tape. One group of H.T.S. insulation used glass-covered wire, glass and mica wrapper, glass tape, and silicone-resin treatment throughout. At the end of the test this insulation proved to have satisfactorily withstood the test and was by far the best of any insulation examined. It must be said that not all the coils having class B

Table 15.—Available Forms of Silicone-Resin Insulation.

Form	Size	Use
Silicone-varnished glass-cloth	Continuous rolls 18 ins. wide. Two thicknesses 0.004 in. and 0.017 in.	Backing for composite insulation
Silicone-glass-mica wrapper	Sheets 18 ins. by 36 ins. Two thicknesses—0.008 in. and 0.010 in.	Coil wrapping
Silicone-glass-mica wrapper	Sheets 18 ins. by 36 ins. by 0.015 in.	Phase insulation in stators
Silicone-varnished glass-covered wire	All standard sizes	Magnet and stator winding
Silicone filling cement		Plastic filling cement—not rigid
Silicone-bonded glass-mica tape	All standard widths. Two thicknesses —0.055 in. and 0.0075 in.	Ground insulation for coils
Silicone-sized glass tape	Widths up to 1 in. Thicknesses up to 0.015 in.	Protective outer wrapping for coils
Silicone-sized asbestos cloth	Sheets 36 ins. by 36 ins. by 0.035 in.	Cushioning material

insulation had failed at the end of this time, but such insulation showed signs of thermal deterioration and embrittlement of the resins. The H.T.S. coils were still about as good as new.

Besides the application to motors, upon which much has already been said, magnet coils of various types have been made with H.T.S. insulation and placed in service on street railway systems. The experience from this is that life is considerably better than that from class B insulation. A laboratory test on the magnet coils still progressing shows to date 5,000 hours of operation at an observed temperature of 235 degrees C. (250 degrees C. hot spot).

Table 16 gives test results on silicone films showing ageing/time/temperature relations. Table 17 shows estimated weight reduction on the basis of additional thermal endurance only. Fig. 29 considers an existing design of traction motor, with increased output merely from increased load. Fig. 30 depicts the type of motor that ended with bearing failure rather than insulation breakdown after 3,376 hours of test, 250 degrees C. hot spot temperature.

Elastomers based on the silicones, and referred to as silicone rubbers, have been developed and exploited by the Dow Corning Co. and by the General Electric Co. The registered trade mark for the former company's synthetic rubbers of this type is "Silastic." Like the other silicones, these materials are not fully developed and as yet far from finality, and little factual information is available. Some data was given in "Materials and Methods," Vol. 27, No. 4, October, 1945.

A number of grades of Silastic are marketed; all of them are characterized by heat resistance superior to that of the natural or conventional synthetic rubbers. A usable temperature range of −70 degrees F. to 500 degrees F. is quoted for the Silastic rubbers, and −60 degrees F.

Table 16.—Failure Time (Hours) of Silicone Insulations.

Ageing temperature degrees C.	14.4% elongation	7.2% elongation	3.6% elongation	1.8% elongation	Craze failure time
250	36	55	63	80	85
225*	225	290	375	500	590
225†	205	314	360	456	485
200*	1,060	1,630	—	—	—
200†	1,160	1,790	—	—	—

* Actual. † Calculated by 10-degree rule.

Table 17.—Weight Reduction of Induction Motor by Increase in Operating Temperature.

	Totally Enclosed Fan-cooled Induction Motors.								
	2 h.p.			15 h.p.			40 h.p.		
	Insulation			Insulation			Insulation		
	A	B	HTS	A	B	HTS	A	B	HTS
Per cent. total wt. ..	100%	79.5%	63%	100%	81%	53%	100%	69.5%	54%
Power-factor	82%	81.5%	79.5%	84.4%	84.3%	84.1%	87%	86%	86%
Temperature rise ..	40°C.	63°C.	113°C.	43°C.	65°C.	125°C.	44°C.	64°C.	106°C.

to 575 degrees F. for the G.E.C. materials. Excellent dielectric properties and water-proofing characteristics are claimed.

Silastic silicone rubber compounds are produced in the form of a white salve-like paste for use as a coating dope for glass and asbestos cloth, for glass and enamelled articles, for ceramics for electrical apparatus, and for the protection of metals such as iron, steel and aluminium.

For cloths and tapes, the glass or asbestos cloth is coated by doctoring or by roller, and cured in the usual type of varnish tower, the baking period being from two to three minutes at 500 to 600 degrees F.

For the treatment of electrical resistances comprising wire windings direct on ceramic formers, up to four applications of Silastic are given by dipping, each coat giving a film thickness of 0.002 in. to 0.003 in. The resulting product withstands severe test specifications, including the thermal shock test of plunging from 275 degrees C. into ice cold water. The same type of coating over vitreous enamelled types of electrical resistance serves the useful purposes of preventing surface leakage at high humidities, protecting against the ingress of moisture should the vitreous enamel coating become checked or cracked from thermal or mechanical damage, as well as providing protection in general against thermal and mechanical shock. If the coating has to be reinforced for reasons of mechanical compression, it can be covered with a serving of fibre glass yarn and then given a further dip coating of Silastic dope.

Tenacious coatings of iron, steel and aluminium are procured by dipping, and such films are oilproof, waterproof and chemically resistant, and suitable for temperatures up to 200 degrees C. Obvious electrical applications in this category are surface treatments for the tank containers of oil-immersed transformers and rectifiers, coverings for cable hooks and racks, and insulation coatings for variety of knobs, handles, control wheels and the like.

Table 18.—Properties of Silastic Stocks now Available for Moulding and Extruding.

	SR–67 Recommended for general extrusion	SR–73 Compression moulding or extrusion
Hardness—shore, A scale ..	70–75	45–55
Density	2.0	1.5
Tensile strength in lb./sq. in. ..	330	200
Elongation	70%	115%
Dielectric constant—1,000,000 cycles	7.5	5.0
Power factor—1,000,000 cycles ..	0.13%	0.18%
Dielectric strength, volts per mil.	500	500

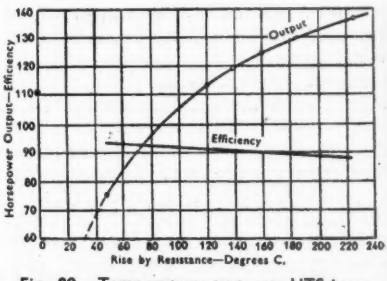

Fig. 29.—Temperature tests on HTS-insulating high-speed self-ventilated traction motor. The results show an increase in output at higher operating temperatures with constant speed.

Flexible laminates are possible using woven glass or asbestos or wire mesh as the reinforcement. These materials can be coated with Silastic, and then multiple layers are moulded together, with a brass sheet between each assembly and the platen. The pressure is applied with the platens cold, and then heated to 150 degrees C. for half an hour for a thickness of ¼ in. Heavier sections can be given longer time or can be given an after-cure in an ordinary oven at 150 to 200 degrees C. for a period of two to ten hours. Maximum strength and stiffness are developed in this manner. Hardness and flexibility are also determined by the grade of Silastic chosen.

The Silastic coating on these materials can be applied in one of the many orthodox methods, i.e., knifing, spreading, roller coating, dipping, or even from solution if thinned stocks are employed. These thinned stocks are specially useful for dipping or spraying.

The laminate can be press-polished for such applications as diaphragms.

These silicone rubber laminates have a wide variety of uses, especially as gaskets and closures, for dustproof seals on covers and cabinet doors, for use as moisture and waterproofing closures, and as oil-resisting gaskets. They can serve over the temperature range from −40 degrees F. to above 300 degrees F., and are particularly attractive when rubber and cork compounds have not the desired resistance to steam, oil and chemicals.

The Silastic coatings can also be applied from solvent solution by dipping or spraying, using petroleum solvents of boiling point below 120 degrees C.; 60-100 degrees C. is preferred. A 40 to 50 per cent. by weight solution is used for dipping, making final adjustment and control by viscosity tests to suit the job. For spray, 20 to 40 per cent. by weight of the silastic is used. The coatings are allowed to dry in air or air circulation without heat to effect the removal of all solvent before thermal curing.

Regarding the thickness of coating that can be applied, the thinner coatings of 2 to 3 mils. can be cured rapidly at high temperatures of 250 to 300 degrees C., while thicker coatings up to 15 mils. are better polymerized more slowly at lower temperatures in the range of 125 to 150 degrees C. The quicker the curing, the more essential it is to maintain uniformity of thickness, otherwise blistering in the thicker areas will be prone to occur. The curing treatments are usually carried out in some form of inert atmosphere. However, it seems that the quick curing at high temperatures can be effected without this refinement. As a guide, the manufacturer quotes temperatures of 250, 275, and 300 degrees C. for coating thicknesses of 3, 2½ and 2 mils. respectively. The time of curing is such as yields a tack-free surface, and it depends upon the thermal capacity of the base material or object, and the time to bring that up to temperature. Thus, whereas coated-glass cloth can be cured in 1 minute at 250 degrees C., a ceramic resistor with a similar thickness of coating may require up to 30 minutes.

For slow curing, carbon dioxide or nitrogen may be used as the atmosphere. Coating thicknesses of 13 mil. use 125 degrees C. and 10 mil. 150 degrees C.,

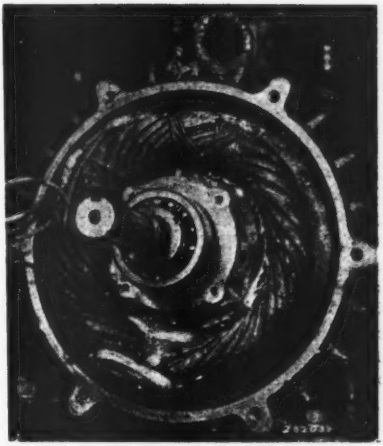

Fig. 30.—The motor shown operated at 250°C. hot spot temperature, the failure after 3,376 hours being due to bearing failure, rather than to insulation.

with at least 30 minutes temperature.

Live steam is also useful as an atmosphere, and, of course, it has the advantage of carrying the heat. Curing time is dependent upon steam pressure, which may range from 35 to 150 lb./sq. in.

The forms of Silastic that are available for extrusion and moulding processes differ fundamentally from ordinary rubbers in their handling, in so far as all preforming, milling and extruding must be done cold, and again in that curing temperatures are higher and times longer. It will be seen, therefore, that processing conditions are not so attractive as physical properties. The maximum physical properties are only obtained if recommended procedures for fabrication are followed.

The die for moulding must not be above 40 degrees C. and is dusted over with talc before filling. It is filled as evenly as possible, and closed with a pressure of 500 lb./sq. in. for a period of one to three minutes. Any entrapped air is released by momentarily relieving the pressure, which is then reapplied. The temperature is raised to 140-150 degrees C., and this temperature held for a period of five to ten minutes. The pressure is not released until the die has cooled to below 40 degrees C., and it is relieved slowly, the die opened, and the article removed. Even then curing is only partial and sufficient to enable the article to be handled. Maximum strength and hardness are developed by curing at temperatures, with time and temperature inter-dependent. Dense articles free from porosity are obtained by various post-curing treatments. One system is to use air-circulating ovens with a slow-rising cycle embracing the following stages:—

1 hour at 80 degrees C.
1 hour at 90 degrees C.
2 hours at 110 degrees C.
2 hours at 130 degrees C.
24 hours at 150 degrees C.

This can be shortened a little by replacing the last two steps by four hours at 150 degrees C. and four to eight hours at 200 degrees C.

This post-curing gives minimum time on the press. If, however, mouldings in service require compression set at high temperatures of 200 to 250 degrees C., it is advisable to perform as much of the after curing as possible with the article still under pressure. This can be achieved if the press is fitted with electrically heated platens by following the normal pressure period at 125-150 degrees C. by at least as much of the 200-250 degrees C. treatment as is practicable.

Silastic can be extruded very satisfactorily to shapes, or over wire, using normal rubber-working machinery. The supplier's recommendations for handling are as follow:—

In premilling, the Silastic needs to be masticated on a two-roll mill or by passing through the extruder before the final extrusion. Temperature must be maintained below 40 degrees C. A smooth uniform extrusion is assured by a mastication period of from five to ten minutes.

Temperature control in extruding is apparently critical. The barrel of the extruder is kept cold, while the head, including the die, is heated from 40 to 70 degrees C., and is adjusted so that the material leaving the die gives the smoothest extrusion. The material temperature is then about 55 degrees C. Too low a temperature causes lack of uniformity. The best procedure for arriving at the optimum conditions is to extrude the material cold and then gradually raise the heat until the best extrusion emerges, thereafter maintaining that set of conditions.

The extruded material is weak and has to be handled carefully, and tension on draw rolls has to be low to prevent wire cores from migrating. The extrusion is treated with talc or its equivalent.

The extrusion next has to be cured to develop its maximum of strength, etc. One method is to cure partially in a steam vulcanizer, following with oven baking. For example, 1 hr. with 40 to 60 lb. steam for the first operation, and then through a cycle of temperatures in an air-circulating oven (1 hr. at 90 degrees, 1 hr. at 110 degrees, and 4 hrs. minimum at 150

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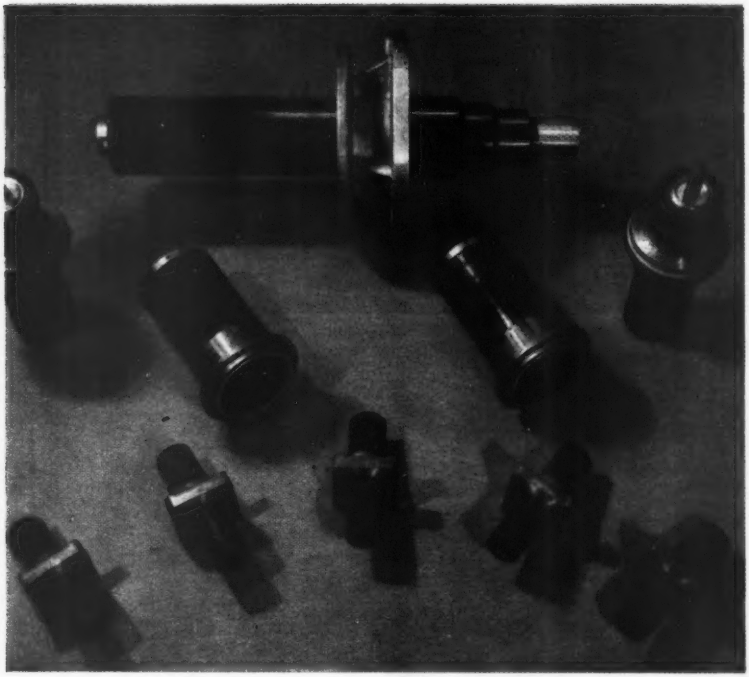

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degrees C.) for after curing. This type of process is advocated for silastic-covered wire. A straight oven curing process in circulated air may entail 1 hr. at 80 degrees, 1 hr. at 90 degrees, 2 hrs. at 110 degrees, 2 hrs. at 130 degrees and 4 hrs. minimum at 150 degrees C.

Actual curing conditions are determined by the cross-section of the wire and the thickness of the coating. Porosity in the ultimate product indicates too short a curing period.

For small sections, the above curing cycles can be shortened somewhat, but if the product is for high temperature service in the range 150-250 degrees C. then a final 24 hrs. at 150 degrees C. should be incorporated in the curing treatment. The need to bring the material up to 150 degrees C. through slow stages is stressed in all cases.

The above information on silastic must, of course, be regarded as preliminary and tentative in view of the early stage of commercialization. It is given here as a guide to the general nature and utility of these materials. Some mechanical and electrical values are likewise given in Table 18.

Briefly summarizing at this stage, the silicon plastics offer to the electrical industry properties of improved thermal resistance, good electrical characteristics, good stability and moisture resistance and impermeability. Their versatility enables them to be available in a variety of forms and conditions, and they can be used with advantage, where such advantage can be exploited on the basis of efficiency, wherever their organic counterparts had previously been used. The high curing temperature must be noted, as likewise must be the generally long curing time. Further, to take advantage of thermal stability, organic material must be excluded from the design and an all silicone-inorganic insulation adopted. In many cases, where, for example, silicone-glass fibre insulation is used in place of organic varnish-textile material, a larger space factor may be required. One foresees, therefore, maximum exploitation in motor and generator fields, large coils, and in heat-resisting silicone rubbers, silicone laminates, silicone mouldings, lubricants, and the like, with all these products restricted to fields in which the merits of the materials can be fully developed to offset the initial cost.

(To be continued.)

Plastic Wire Cloth

The United States output of plastic wire cloth for screens during 1946 is expected to double the record quantity of 40 million sq. ft. per year produced during the war. There is a large pent-up demand for screens, and a present shortage of metal wire screen. Manufacturers are of opinion that, even when metal screening is again in plentiful supply, plastic wire cloth will retain its present position, as it retails at about the same price as bronze wire cloth.

Sealing Porous Rock in Oil Wells

Tests carried out with a phenolic resin in a West Texas oilfield indicate that it may be possible to return the average well to its normal production after allowable output has dropped as low as one barrel daily, due to the intrusion of unwanted gas. Developments have been jointly in the hands of the Monsanto Chemical Co., of St. Louis, and Oilwell Chemical Service Co. The resin has been used as deep as 11,500 ft. underground. It is introduced into the well shaft as a liquid, which permits maximum penetration, and hardens after it has permeated the porous rock through which natural gas has been filtering.

I.P.I. GOLFING SOCIETY.—The London Section of the Institute of the Plastics Industry Golfing Society announce the following forthcoming arrangements:—

Saturday, July 20.—Match against "The Times" Golfing Society, at West Hill Golf Club, Brookwood, Surrey.

Wednesday, July 24.—All-day meeting at Sandy Lodge Golf Club, Northwood, Middlesex, to compete for the Cyril Last Trophy (morning) and the F. A. Hughes Trophy (afternoon).

Planned Mould Maintenance Service Aids Economical Production

Section XX (contd.)

By W. M. HALLIDAY

Continuing the consideration of drum-type insert feeding mechanisms as applied to injection moulds, attention is here devoted to the study of the design, mechanical and operational features of fully automatically operated drum feeds

It is very often desirable to feed inserts into the mould cavity at an inclination to the parting-line surface, and a very useful and interesting form of mould construction permitting fully automatic feeding of inserts in such a manner will be illustrated and described.

Throughout, as usual, special attention is focused upon those constructional forms and methods which have been found to afford smoothest functioning and smallest amount of maintenance oversight.

READERS who have very carefully studied the injection mould design and particularly that portion of the mechanism covering the feeding of the inserts, which was illustrated and considered in last month's issue of this journal, will doubtless readily appreciate that the feature of manual operation of the insert feed drum integral with the construction possesses one important disadvantage, i.e., that of drastically slowing down production due to the handling time required on the part of the operator for actuating the drum after the mould blocks have been brought to their open position.

To meet the requirements of large-scale and rapid production, reduction in such handling time can usually be effected by substituting such hand motions by purely mechanical ones, which may be either motivated from the normal opening motions of the mould blocks, or by a completely external source of power.

It is the chief purpose of this section, therefore, to deal with a few very simple but effective types of mould constructions embodying automatic operation of the insert feeding mechanism, once again laying special emphasis upon those preferable forms and constructions known by experience to be of the greatest assistance and value to the maintenance toolmaker.

In the present article attention will be confined to the consideration of a few designs, all of which are actuated in one common manner, i.e., by the normal opening or closing motions of the mould blocks themselves.

Mould constructions in which the insert feeding device is operated by an outside source of power, such as by pneumatic cylinders connected to an external air supply, will form a most interesting study for a later section, and will be dealt with at the first opportunity.

Reasons for Fully Automatic Feeding of Inserts

Very often the substitution of automatic for hand operation of the insert feeding mechanism not only results in increased output by shortening the loading cycle between "shots," but ensures one further important advantage, which is far greater precision in the indexing and location of the inserts within the cavity area. As will be appreciated, this may be a vital concern for the mould designer on certain types of mould, where the number of inserts is large.

As will readily be understood with hand-operated devices such as have already been dealt with in earlier pages, there always exists the risk of an unobservant operator unwittingly moving the feed drum too far round because of excessive turning pressure exerted on handle. Contrariwise, too light a pressure on the handle may similarly cause a misplacement of the drum in relation to the magazine chute. Or again, due to

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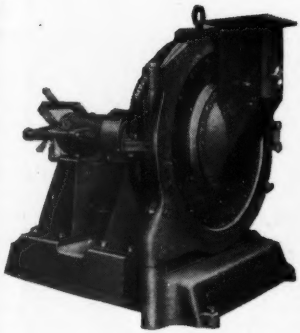

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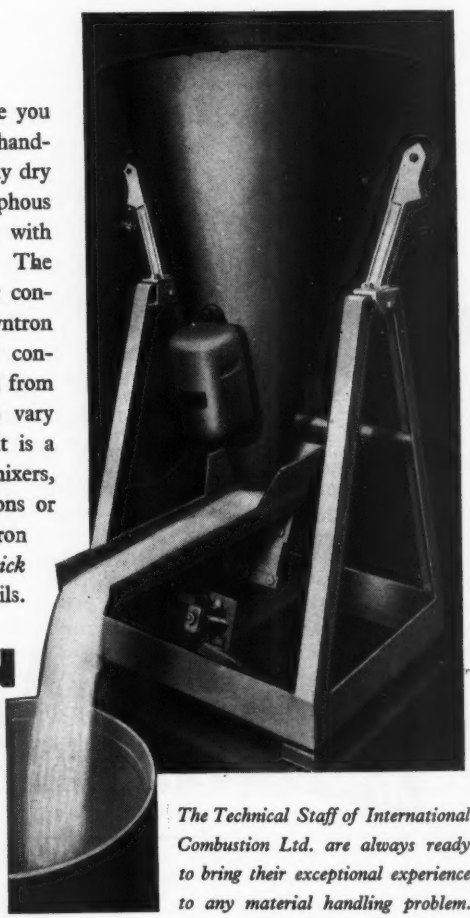

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faulty manual operation, certain seatings in the feeding drum may fail to receive an insert component during the loading movement.

Such failures as these, and others which could be mentioned at length did space allow, may cause serious mould breakdown by allowing the inserts contained in the drum seatings to become out of line with the holes in mould block at base of cavities. Trapped insert parts, bent or fractured push pins, jammed feed drums, additional wear between drum and its housing in block, tightening up of slide movements, etc., are some of the undesirable occurrences resulting from unintelligent manual operation.

One great advantage derived from the purely mechanical operation of the drum movements is that each one can be accurately regulated and controlled to the same degree of pressure or distance, whilst the indexing round of the drum as in the case of a multi-insert type of drum can be held within very fine limits of error. The result is that all the aforementioned troubles are more readily obviated, hence the added inducement to employ automatic feeding mechanisms, even though adoption of same leads to extra initial cost of the moulds as against the simpler manually operated type.

Yet another reason inducing the choice of automatic feed is that usually it is much easier and useful to arrange for purely mechanical sorting and locking of inserts prior to location within the cavities as well as during the actual injection shot. With manual operation these additional and often necessary functions entail the use of extra levers, etc., to be operated by hand, whereas with the automatic feeding device generally it is possible to include all the essential movements within one design of mechanism, and, of course, all being actuated from the same power source. As will be realized, this not only makes for speedier production, but often enables a more simple and less cumbrous mechanism being used.

Another important advantage not always realized is that with the use of fully automatic insert feeds the thermal balance of the injection mould as a whole during production runs is less liable to be upset, hence improved mouldings are easier to produce. This arises from the fact that with hand operation of the feed drum, etc., *varying amounts of time are absorbed*. One movement may take a quarter of a minute, the next may require or at any rate take half a minute. Such variations over lengthy periods may result in wide oscillations in the mould temperature, with consequent departure of surface finish, and homogenity of the moulded articles from desirable standards. Such a feature will be specially valuable in instances where the mould cavity or cavities have to be fed with a large number of inserts, which of themselves will tend to lower the mould heat. This, of course, is an important mould operating objective and somewhat beyond the scope of this series of articles, but the originating cause of such troubles may be remarked here with benefit.

Automatic Drum Feed for Eight-impression Mould

Turning now to the first mould example chosen and shown in Fig. 1, it will first be noticed that this is a tool essentially to the same design as that illustrated in "Plastics," June, pages 324 and 328.

This is an eight-impression mould having a cavity layout requiring the insert members to be fed at right angles to parting-line from the rear into seatings provided at base of each cavity, as indicated in the sectioned view herewith of the movable block.

This portion of the injection mould only is here shown as it contains all the relevant mechanism of the automatic feeding arrangements. The cavities are disposed at the same radius from the centre sprue, and located exactly the same distance apart. This incidentally is a very important requirement, since cavity location of this kind very greatly facilitates the construction and functioning of the feeding drum.

Usually in those mould designs where it is impracticable to locate the cavities on the circumference of a circle around the

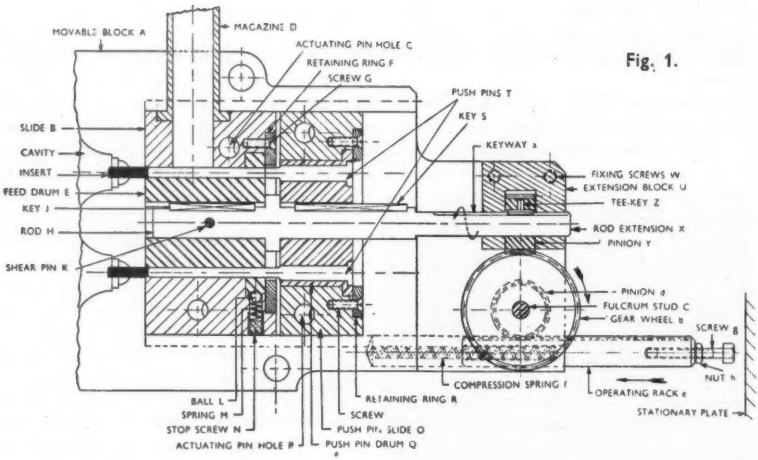


Fig. 1.

sprue, or equally apart considerable difficulties will be experienced in fashioning a satisfactory feed drum. In such circumstances it will be necessary to make the size of feed drum large enough to suit the cavity at the greatest radius, and to make all the other insert seatings in the drum deeper so as to match their respective cavities. In addition, it will be essential to equip the mould with a suitable interlocking device to ensure that the drum comes to the same point for loading.

The movable mould block is excavated substantially on its rear side in order to receive suitable guideways for the feed drum slide B and the push pin slide O. Both these members are fitted to be a free sliding fit, but all unnecessary clearance or slackness is obviated. Although such provisions are not here illustrated, it will be advisable to install these slides with some means for effectively taking up any wear, and the method of brass gibe as previously dealt with in an earlier section will be found as satisfactory as any method which can be adopted.

As will be seen, the direction of travel of both slides is located exactly at right angles to the parting-line of the mould, or in other words in the same axial plane as that of the centre line of each cavity to be fed with an insert.

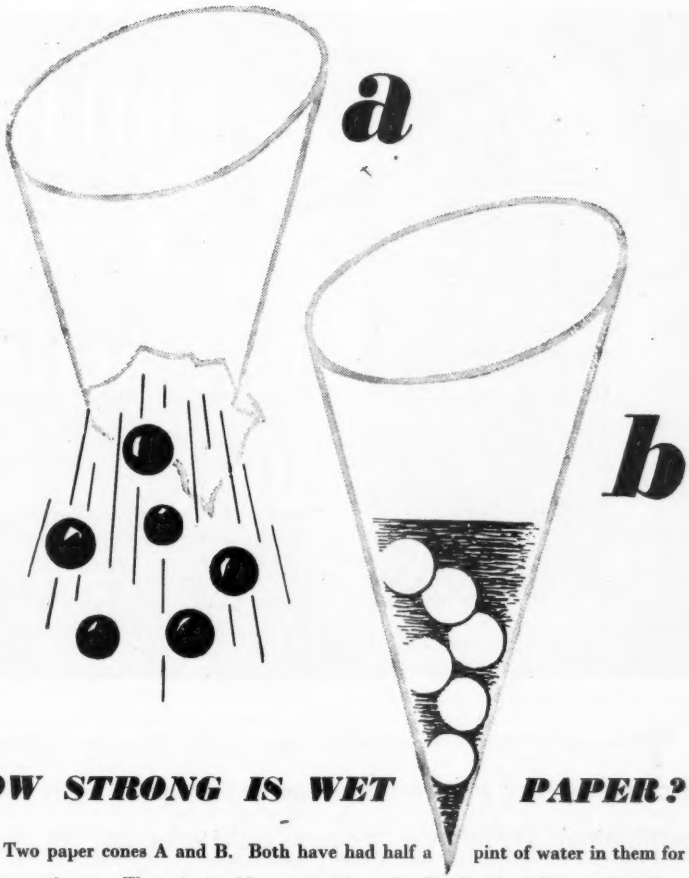
Slide B is moved by means of a pair of angularly disposed pins affixed to the stationary mould block, and not shown here, these engaging with the actuating pin holes C indicated in Fig. 1. Here again these holes should preferably be lined out with hardened and easily replaceable bushings so that any wear may easily be taken up.

Attached to the top of slide B is the hollow tubular member D which is the magazine for holding a large number of insert components. The inside dimensions and shape of this tube are rectangular and large enough to afford adequate clearance to an insert piece, which should be free enough therein to fall by their own weight.

The magazine is located at right angles to the slide as shown.

The Feeding Drum

The larger of the two slides, viz., B, is bored out clean through its centre portion to take the cylindrical feed drum member E, which is made a close rotating fit within the bore. The drum itself is provided with an enlarged flange at its right-hand end, this being seated easily within a recess turned in the end face of the slide as shown. Undue endwise movement of this drum other than that



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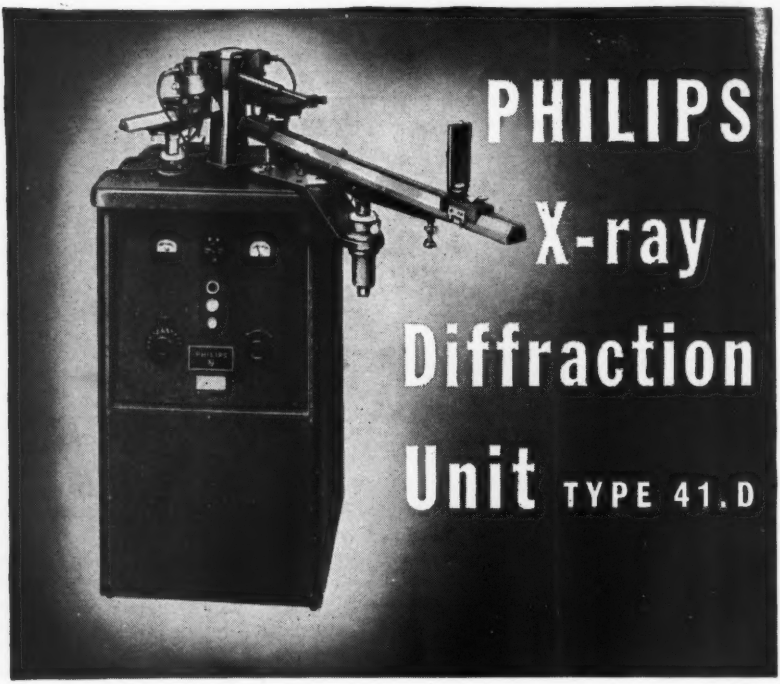

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required for free working is precluded by the bronze retaining ring F, which is securely attached to the bottom of slide recess by means of the countersunk-headed screws as at G.

As mentioned earlier, it will be advisable to harden and grind the surfaces of the feed drum, and also to harden and grind out the bore of slide in which it has to be housed in order to obviate early wear and misalignments.

The diameter of the shanked portion of the feed drum is again made the same distance as the centres of the seating holes carrying the inserts in block plus the diameter of one insert piece.

Eight holes are drilled axially through the drum E, these being spaced radially and equally centred to each other so as to make them exactly match up with the holes running through block into base of cavities. From the base of the magazine tube to the bored hole in which the drum is located a rectangular shaped slot is machined in the slide to the same dimensions as those inside the tube, thus forming an unbroken extension of the latter clear through to the shank of the drum. Thus insert components housed within the magazine will be free to fall into the appropriate holes formed in shank of the drum.

Rotation of the feed drum E is accomplished by means of the rod H, which is made a press fit within the small bored hole up centre of drum. A small feather key as shown at J serves to secure both members together. If desired, and in some constructions it might prove advisable as an additional safety measure, this key may be dispensed with and a shear pin, as at K, employed instead, this being tightly driven into a cross-drilled hole passing through both rod and drum. If this shear pin is made of suitable soft material any undue load or resistance encountered by mechanism will be compensated by breakage of the pin.

Accurate indexing of the drum is secured in an identical manner as in the case of the previously illustrated mould design, i.e., by means of a hardened steel ball L backed by spring M and the stop screw N, all secured in the lower side of slide B and engaging with dimples machined in the flange of drum.

The Push-pin Slide

The second smaller slide O is actuated by means of a set of inclined pins in the stationary block bearing in the inclined holes P. As in the case of slide B, this member is bored out to receive the cylindrical push-pin drum Q, this being prevented from endwise movement by the retaining ring R, which is held in place within the recess in endface of slide by a number of small screws.

Rod H passes through the bored hole in centre of the drum Q, and the feather key S is made a sliding fit within the keyway cut in drum bore. This ensures that the drum is free to slide along the rod, but rotates in unison with that member.

Eight push pins T are affixed to the drum, as shown, these being long enough to pass through the feed drum E the required amount.

Construction of Automatic Drive

At this point the construction of this mould departs from that described in last month's issue, in that a fully automatic drive is imparted to the mechanism just indicated.

To accomplish this, an extension block U is very securely affixed to the end face of the movable block by means of fixing screws W. This block is situated so as to form a bearing and support for the rod H, which is similarly extended and reduced in diameter at this point X for a sufficient distance as will be made clear.

The bearing block U is slotted in order to accommodate a mild steel helical toothed pinion wheel as at Y, this being secured to the rod H in the following manner. A tee-shaped key shown at Z is secured to the keyway in the pinion and made a sliding fit within the keyway a. This latter is cut clean out of the end of the rod H to allow for easy admittance of the pinion during assembly, or ready removal of same during inspections or cleaning operations.

Meshing with pinion Y is the large helical gear wheel b, this member having twice the number of teeth as its mating pinion. Secured to the left-hand side of this gear is a smaller spur-type pinion d having half the number of teeth as the gear. This combined gear is arranged so as to rotate freely upon the fixed stud c, which is fastened down to the extension built on to side of movable block.

The steel operating rack member e is housed so as to slide freely within a horizontally bored hole machined within the extension block U as indicated. One side of this member e is machined with gear teeth so as to allow it to mesh correctly with the small pinion d. The right-hand end of the rack is drilled and tapped to take the screw g and the lock-nut h, these affording very convenient adjustment facilities, as will be explained later.

Return of the operating rack from left to right is obtained by means of the very stiff compression spring f which is housed within the bored hole extending for a substantial distance up the left-hand end of rack. The bearing hole in the extension block U is also closed at one end to serve as stop for the left-hand end of the spring.

Method of Operation of Automatic Feed

From the foregoing description readers will doubtless have gained a clear picture of the method of operation, since this is a very simple arrangement.

First of all the pinions and gear wheel just described must be carefully calculated out in order that each may have the requisite number of teeth to secure one complete revolution of the feed drum mechanism for the amount of longitudinal travel of the movable block which it is permissible to employ.

After an injection shot has been made the mould blocks are parted, movable block A travelling towards the right. The initial portion of this movement causes the two slides B and O, respectively, to be withdrawn along their guideways. During this movement the rod H merely slides through the push pin drum and the pinion and its bearing in the extension U. No rotation is imparted to the gears and the rod H until the adjusting screw in the right-hand end of the operating rack has travelled sufficiently to contact the stationary plate which is affixed across the machine guide rods, or to the end-plate tie-rod casting. Immediately such contact is made continued movement of the mould block to the right causes the rack to be depressed within its housing hole, against the pressure of the spring f which is thereby compressed.

As the rack is thus forced within its housing it operates the combined pinion and gear on fulcrum stud c, this member in its turn actuates the pinion Y on the rod R, thus causing the feed drum and push pin drum to be rotated.

By adjusting the screw g it is possible to obtain variations in the amount of movement of the rack, and thus the extent of rotation of the drums. Extremely fine adjustment is thus obtainable so as to give very accurate indexing of the feed drum.

When the movable block has reached the limit of its travel towards the right, thereby being in its extreme open position, the gearing should have been operated sufficiently to bring the feed drum with its housing holes exactly in line with the seatings in block.

The speed of rotation can be controlled so as to take place fairly slowly, thus allowing an insert member to fall down into the seating slots in the feed drum as this is slowly rotated within the slide. After the movable block has reached the end of its opening movement no dwell will be necessary since the drum will then be fully loaded with its correct complement of inserts. The moulds may then be closed and a further injection shot taken in usual manner as the closing blocks will cause the two slides to move inwards, pushing the inserts forward into the mould cavity area as illustrated in Fig. 1, this illustration showing the position of the mechanism immediately prior to the injection shot.

(To be continued)

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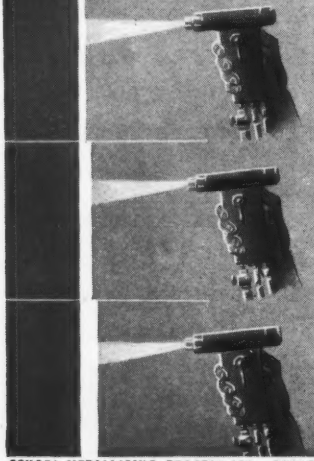

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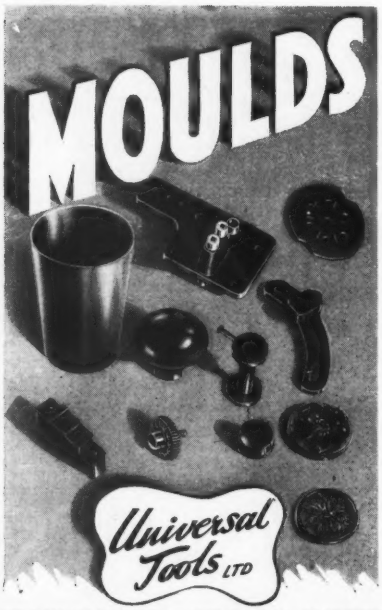

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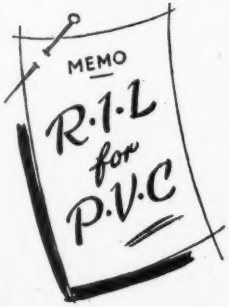

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